CALIBRATION OF GPS INSTRUMENTS USING GPS NETWORK TEST FOR HIGH ACCURACY APPLICATION

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By

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FINAL YEAR RESEARCH PROJECT REPORT

Submitted to the Civil Engineering Programme
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Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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Approved by,

(Dr. Abdul Nasir Matori)

UNIVERSITI TEKNOLOGI PETRONAS

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and the original work contained herein have not been undertaken or done by unspecified sources of persons.

MUHAMMAD ZAHIED BIN MOHD NOOR

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ABSTRACT

The objectives of this project are to perform the calibration procedures on the GPS instruments and to check the accuracy and precision of them. By using the GPS Network Test, the accuracy and precision of the equipment could be checked and analyzed. Application of GPS is extensively used nowadays. GPS can be used for many applications such as land application, air application, marine application, space application and military application. The important used of GPS which to get precise and accurate results is made it necessary for the equipment to carry out the calibration. Scope of study for this project covers the topics which are the studies of GPS receiver, GPS control station, GPS surveying procedures and GPS data processing. Steps or procedures involve in this projects are the selection of GPS control stations, fieldwork planning, conducting GPS surveying or observation, processing the GPS data, analyzing the results and discussion over the results. At the end of this project, a certain recommendation will be made for the GPS instrument based on the analysis of results obtained from the calibration procedures.

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND NOMENCLATURES

GPS	-	Global Positioning System
JUPEM	-	Jabatan Ukur dan Pemetaan Malaysia (Department of Survey and Mapping Malaysia, DSMM)
PC-CDU	-	A software used to transferred the raw data from the GPS receiver to the Computer

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Global Positioning System (GPS) is a satellite-based navigation system that was developed by the U.S. Department of Defense in the early 1970s as the next generation replacement to the Transit system. Initially, GPS was developed as a military system to fulfill US military needs. However, it was latter made available to civilians, and is now a dual-use system that can be accessed by both military and civilian users.

GPS provides continuous positioning and timing information anywhere in the world under any weather conditions. Since GPS is a one-way ranging (passive) system, it serves an unlimited number of users as well as being used for security reasons. That is, users can only receive the satellite signals.

A GPS system testing/calibration program is considered as a prerequisite for demonstrating "competence" and for assuring that GPS-derived coordinates are of a uniformly high quality [1]. Calibration of GPS instrument is the procedure which is done to describe tools or other devices of GPS to determine whether they are in good condition or not before doing any works.

The GPS works and application such as for monitoring structural deformations, marine seismic surveying and many more require the equipment or instrument which is in the be st condition in terms of accuracy and precision. Therefore, before any GPS works are done, GPS itself has to be tested to ensure accuracy and precision of its results.

The testing of GPS is intended to validate the particular GPS technique or an individual piece of receiver equipment. GPS testing may involve a few possibilities which are;

- Testing of the GPS system
- Testing of the user segment, involving the combination of hardware and software
- Testing of the GPS instrument
- Testing of the skill of personnel, which are infield and data processing procedures

The GPS tests can be divided into four categories which are Accreditation Test, Certification/Calibration Test, Validation Tests and Quality Assurance Practices and Verification. For this project, the category of GPS test used is Certification/Calibration Test which known as GPS Network Test. It is performed in order to ensure that the operation of GPS receivers, associated antennas and cabling, and data processing software, give high accuracy coordinate results.

The test is done to compare the coordinates of GPS Control Stations obtained from observation of GPS at three selected control stations against the coordinates of the control stations itself that have been tested and established by Department of Survey and Mapping Malaysia (DSMM) or famously known as JUPEM (Jabatan Ukur dan Pemetaan Malaysia).

GPS Control Stations are marks that were set up to form a control network connected to the National Reference Frame of GDM2000 through the use of GPS measurement technique. Currently, there are about 238 GPS Control Stations which are established as the Peninsular Malaysia Primary GPS Network 2000 (PMPGN2000) and 171 GPS Control Stations which are established as the East Malaysia Primary GPS Network 2000 (EMPGN2000). These control stations are used as control in mapping, cadastral surveys, military, scientific studies and etc [2]. Figure 1 is the example of the monument of control station from the top view.

Figure 1: GPS Control Station

The GPS Control Station has a plate and bolt, mounted on top of a concrete monument jutting out from the ground surface. Some of these control stations are re-used triangulation pillars or fundamental benchmarks. All of the GPS Control Stations have coordinates of the same high quality, and are equally good for the purpose of controlling GPS surveys in the GDM2000 coordinate system [2].

GPS surveying is a technology which develops gradually nowadays. Some characteristics of GPS Surveying are the points being coordinated are stationary, the data are collected over some observation sessions, mode of operation is relative positioning which can give high accuracies, requiring special instrumentation and software because the measurements are made on the L-band carrier wave and it is mostly associated with the traditional surveying and mapping functions [3].

The basic procedures of GPS static positioning covers the antenna setup and height measurement, and also the synchronizing of observation sessions. The following are some procedures that should be adhered to in the antenna setup and height measurement [3].

- The antenna normally bears a direction indicator that should be oriented in the same direction at all sites using a compass.
- The same antenna, receiver and cabling should be maintained together
- Centering of the antennas is very important to get the high precision of data
- The antenna assembly should therefore be mounted on a standard survey tribrach with an optical plummet, on a good quality survey tripod
- The height of the antenna above the station marker, measured from the standard reference point on the antenna housing should be measured to the nearest millimeter. This should be done at the beginning and at the end of each session.

To synchronize the observation sessions, all receivers must track during the same time period. The receivers also must track the same constellation of satellites and all receivers must record data for the same epochs to within a few microseconds [3].

GPS data processing involves the steps which are data pre-processing, initial data analysis and final adjustment. Figure 2 shows the sequence of the basic of GPS data processing steps.

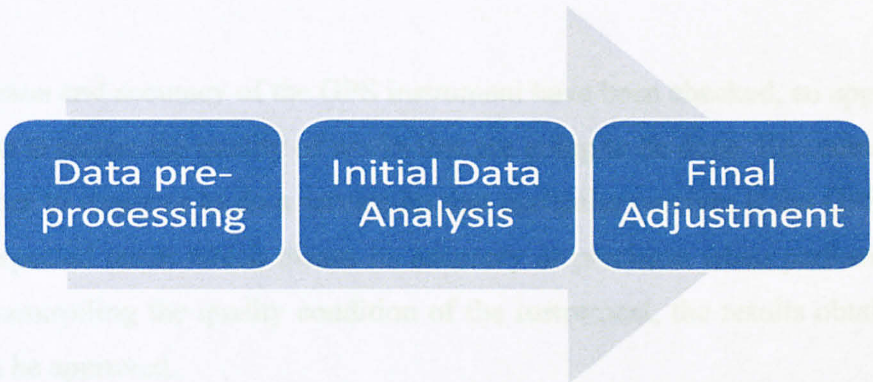

Figure 2: Steps in GPS Data Processing

1.2 Problem Statement

Application of GPS nowadays has become very important as GPS can provide high-accuracy positioning in a cost-effective manner. GPS are widely used in land, marine, and airborne applications. Some of the GPS applications are for the utility industry, forestry and natural resources, precision farming, Civil Engineering applications, monitoring structural deformation, open-pit mining, land seismic surveying, marine seismic surveying, airborne mapping, seafloor mapping, vehicle navigation, retail industry, cadastral surveying etc [4]. All these are high accuracy application of GPS and it is important to have an instrument which is in excellent condition to perform the tasks.

1.2.1 Problem Identification

To maintain the high accuracy positioning as to get the best results, the GPS should be tested in order to know the condition of its instrument. As explained earlier, there are many strategies or ways of testing the GPS. The selection of testing methods depends on the cost, time and other criteria. It also depends on the individual or organization to choose the method which best suit the purpose of the work.

Once the precision and accuracy of the GPS instrument have been checked, an appropriate action should be taken to ensure the quality of works that are going to be done. Recommendation could be made whether to repair or to do a service on that particular receiver if the GPS receiver does not give the expected result which means its accuracy or precision when performing the test is low. Only by controlling the quality condition of the instrument, the results obtained using that instrument can be approved.

1.2.2 Significant of the Project

This project concerns about the importance of calibration of GPS instrument before any GPS works are conducted. The best results of using GPS will only be obtained from the excellent condition tools and good practices or surveying skills. By doing calibration, the condition of GPS instrument can be checked.

GPS instruments in Civil Engineering Department Laboratory of Universiti Teknologi PETRONAS (UTP) are used widely by students for their project and also for the purpose of learning. The question is, how accurate are the results obtained by using the GPS instrument? It is because they never know the condition of the instrument in term of its accuracy. At the end of this project, the accuracy and condition of the instrument will be determined. If the instruments are not in good condition, they should be serviced or repaired. So, this will definitely give benefit to UTP and UTP students as well.

Another significance of this project is, it can be used as a guide for students or anybody who wants to do a research or project related to GPS because this project can provide much information about GPS which can assist them in their works.

1.3 Objectives and Scope of Study

The objectives of doing this project are;

- To perform the calibration procedure on the GPS instrument
- To check the accuracy and precision of the GPS instrument

Before performing the calibration procedure on the instrument, selection of the best three control stations should be carried out. The selection of the control station to be used must be according to the field test criteria. After selecting the control stations, proper planning should be done to ensure the smoothness of the GPS observation. The important elements in the planning are logistical considerations, instrumentation and personnel involved.

Certain procedures and guidelines should be followed during the GPS observation. This is to ensure that the data observed is good and errors can be reduced. Processing the data using the GPS data processing software is done after downloading the data from the receiver. The results from the processed data such as the coordinates in RSO will be compared to the established coordinates of RSO established by JUPEM. From the analysis of the results, the precision and accuracy of the receiver can be determined and the condition of the instrument will be known whether it is in good condition or not.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Overview of GPS

GPS consists, nominally, of a constellation of 24 operational satellites. This constellation was completed in July 1993, which was known as the initial operational capability (IOC). The official IOC announcement, however, was made on December 8, 1993. To ensure continuous worldwide coverage, GPS satellites are arranged so that four satellites are placed in each of six orbital planes. With this constellation geometry, four to ten GPS satellites will be visible anywhere in the world, if an elevation mask of 10 degree is considered. As discussed later, only four satellites are needed to provide the positioning, or location, information.

2.2 GPS Segments

GPS consists of three segments: space, control, and user. The space segment consists of the 24 satellite constellation. Each GPS constellation transmits a signal, which has a number of components which are two sine waves (also known as carrier frequencies), two digital codes (or more for modernized GPS satellites), and a navigation message. The codes and the navigation message are added to the carriers as binary biphase modulations. The carriers and the codes are used mainly to determine the distance from the user's receiver to the GPS satellites. The navigation message contains, along with other information, the coordinates of the satellites as a function of time. The transmitted signals are controlled by highly accurate atomic clocks on board the satellites. Figure 3 shows the GPS space segment.

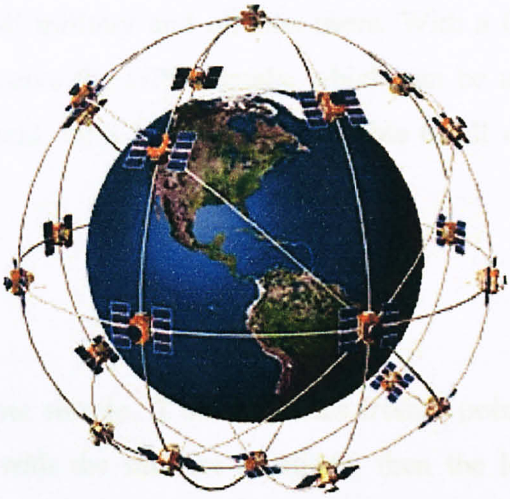

Figure 3: GPS Space Segment [9]

The control segment of the GPS system consists of a worldwide network of tracking stations, with a master control station located in the United States at Schriever Air Force Base near Colorado Springs, Colorado. The primary task of the operational control segment (OCS) is to track the GPS satellites using a number of monitoring station in order to determine and predict satellite locations, system integrity, behavior of the satellite atomic clocks, atmospheric data, the satellite almanac, and other considerations. This information is then packed and uploaded to the GPS satellites by the ground antennas through the S-band link. Figure 4 shows the location of control segment of GPS.

Figure 4: GPS Control Segment [9]

The user segment includes all military and civilian users. With a GPS receiver connected to a GPS antenna, a user can receive the GPS signals, which can be used to determine his or her position anywhere in the world. GPS is currently available to all users worldwide at no direct charge.

2.3 Basic Idea of GPS

The idea behind GPS is rather simple. If the distances from a point on the Earth to three GPS satellites are known along with the satellite locations, then the location of the point can be determined by simply applying the well known concept of resection.

GPS satellite continuously transmits a microwave radio signal composed of two carriers, two codes (or more for modernized satellites), and a navigation message. When a GPS receiver is switched on, it will pick up the GPS signal through the receiver antenna. Once the receiver acquires the GPS signal, it will process it using its built-in processing software. The partial outcome of the signal processing consists of the distances to the GPS satellites through the digital codes known as the pseudoranges and the satellite coordinates through the navigation message.

2.3 Application of GPS

GPS has revolutionized many fields since its early stages of development. Although GPS was originally designed as a military system, its civil applications have grown much faster. GPS has numerous applications in land, marine, and air navigation. On the surveying side, GPS has replaced conventional methods in many applications. GPS positioning has been found to be a cost-effective process, in which at least a 50% cost reduction can be obtained whenever it is possible to use the so-called real-time kinematic (RTK) GPS, as compared with conventional techniques. In terms of productivity and time saving, GPS could provide more than 75% time saving whenever it is possible to use the RTK GPS method [4].

2.3.1 Civil Engineering Application

As everybody knows, Civil engineering works are often done in a complex and unfriendly environment, making it difficult for personnel to operate efficiently. The ability of GPS to provide real-time submeter and centimeter-level accuracy in a cost-effective manner has significantly changed the civil engineering industry. Construction firms are using GPS in many applications such as road construction, earth moving, and fleet management.

2.4 GPS Relative Positioning

GPS relative positioning, also called differential positioning, employs two or more GPS receivers simultaneously tracking the same satellites to determine their relative coordinates (see figure 5). Of the two receivers, one is selected as a reference, or base, which remains stationary at a site with precisely known coordinates. The coordinates of the other receiver, known as the rover or remote receiver, are unknown. They are determined relative to the reference using measurements recorded simultaneously at the two receivers. The rover receiver may or may not be stationary, depending on the type of the GPS operation [4].

A minimum of four common satellites are required for relative positioning. However, tracking more than four common satellites simultaneously would improve the precision of the GPS position solution. Generally, GPS relative positioning provides a higher accuracy than that of autonomous positioning. Depending on whether the pseudorange or carrier-phase measurements are used in relative positioning, an accuracy level of a few meters to millimeters, respectively, can be obtained. This is mainly because the measurements of two or more receivers simultaneously tracking a particular satellite contain more or less the same errors and biases. The shorter the distance between the two receivers is, the more similar the errors. Therefore, if we take the difference between the measurements of the two receivers, common errors will be removed and those that are spatially correlated will be reduced depending on the distance between the reference receiver and the rover [4].

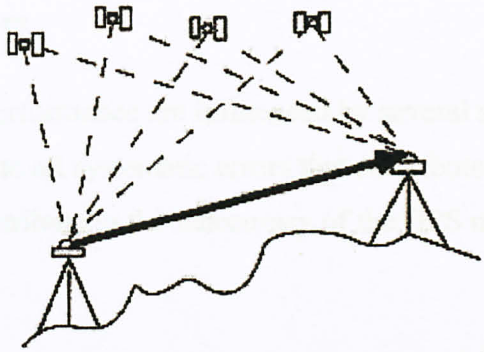

Figure 5: GPS Relative Positioning [10]

2.4.1 Static GPS Surveying

Static GPS surveying is a relative positioning technique that depends primarily on the carrier-phase measurements [4]. It employs two or more stationary receivers simultaneously tracking the same satellites. One receiver, the base receiver, is set up over a point with precisely known coordinates and the other receiver which is the remote receiver is set up over a point whose coordinates are unknown. The base receiver can support any number of remote receivers, as long as a minimum of four satellites is visible at both the base and the remote sites.

In principle, this method is based on collecting simultaneous measurements at both the base and remote receivers for a certain period of time, which, after processing, yield the coordinates of the unknown point. Static GPS surveying with the carrier-phase measurements is the most accurate positioning technique. This is mainly due to the considerable change in satellite geometry over the long observation time span.

2.5 GPS Sources of Errors

The GPS measurement and performance are influenced by several sources of measurement errors. Range bias is referred to all systematic errors that contribute to the measurement error. The sources of errors that contribute to the inaccuracy of the GPS measurement are such the following;

- Receiver noise
- Ephemeris errors
- Clock stability
- Ionosphere delays
- Tropospheric delays
- Multipath disturbance
- Human errors

Noise errors are the combined effect of PRN code noise (around 1 m) and noise within the receiver noise (around 1 m). Satellite ephemeris errors are errors in prediction of a satellite position that may then be transmitted to the user in the satellite data message. This type of error is difficult to be corrected due to many forces acting on a predicted satellite orbit that are difficult to be measured directly.

Clock stability is influenced by the Control segment of GPS. The errors uncorrected by Control Segment can result in 1 m errors. Multipath disturbance is caused by reflected signals from surfaces near the receiver that can either interfere with or be mistaken for the signal that follows the straight line path from the satellite. Multipath is difficult to detect and sometime hard to avoid. Control segment mistakes due to computer or human error and user mistakes, including incorrect geodetic datum selection can also cause errors from one meter to hundreds of kilometers (American Society of Civil Engineers (2000)). Variety of biases and errors that affect the GPS pseudo-range and carrier phase measurements are illustrated in figure 6.

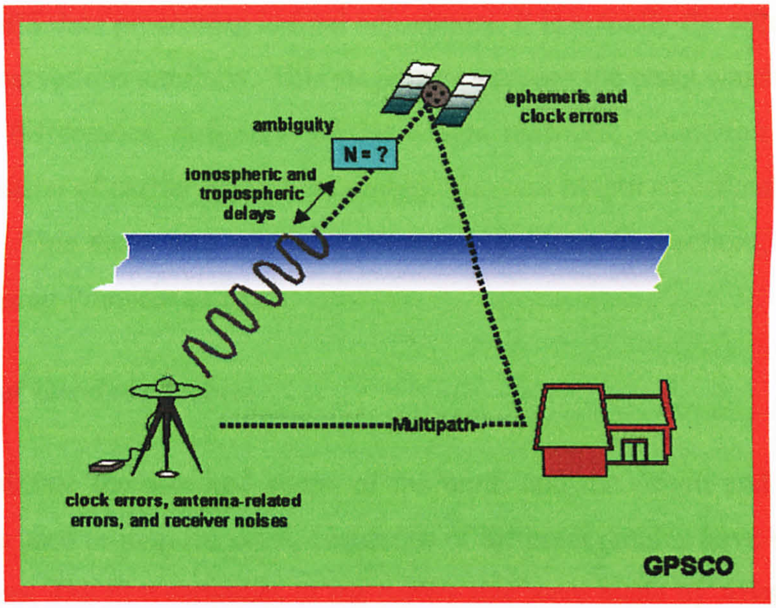

Figure 6: Biases and Errors that affect GPS observation [3]

2.6 GPS Data Processing

There are three stages of GPS data processing as shown in figure 2 before. The first stage of GPS data processing which is data pre-processing involves several tasks; initial data transfer and decoding, data screening and editing, data reporting and database creation and entry and lastly, point positioning using pseudo-range data. In this project, data pre-processing will be done using PCCDU software. The process of using this software will be explained in section 3.8.1.

The second stage of GPS data processing is initial data analysis. It is carried out as a prelude to the final phase data adjustment, as soon as data from the receiver has been downloaded to the computer. The tasks that will be carried out under this stage are; cycle slip detection and repair and preliminary baseline solution. Pinnacle software is used to perform the tasks in this stage. The result obtained at the end of the stage is a clean set of observations, and appropriate station coordinates.

The last stage of GPS data processing is final adjustment. It is actually the adjustment of the pre-processed GPS observations similarly. This stage encompasses the tasks which are the formation of the phase data differences, definition of the weight matrices, estimation of relative station coordinates, estimation of carrier beat phase ambiguities and output of estimated parameters and covariance matrix. This stage also will be performed by Pinnacle. Section 3.8.2 explained the steps involved in using Pinnacle software.

2.7 Overview of Geodetic Datum

Geodetic datums define the size and shape of the earth and the origin and orientation of the coordinate systems used to map the earth. Hundreds of different datums have been used to frame position descriptions. The first estimates of the earth's size were made by Aristotle. Datums have evolved from those describing a spherical earth to ellipsoidal models derived from years of satellite measurements [9]. Modern geodetic datums range from flat-earth models used for plane surveying to complex models used for international applications which completely describe the size, shape, orientation, gravity field, and angular velocity of the earth [9].

Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of meters. Different nations and agencies use different datums as the basis for coordinate systems used to identify positions in geographic information systems, precise positioning systems, and navigation systems. The diversity of datums in use today and the technological advancements that have made possible global positioning measurements with sub-meter accuracies requires careful datum selection and careful conversion between coordinates in different datums [9].

Datum types include horizontal, vertical and complete datums. Hundreds of geodetic datums are in use around the world. The Global Positioning system is based on the World Geodetic System 1984 (WGS84) [9].

2.7.1 Latitude, Longitude and Height

The most commonly used coordinate system today is the latitude, longitude, and height system. The Prime Meridian and the Equator are the reference planes used to define latitude and longitude. The geodetic latitude of a point is the angle from the equatorial plane to the vertical direction of a line normal to the reference ellipsoid. The geodetic longitude of a point is the angle between a reference plane and a plane passing through the point, both planes being perpendicular to the equatorial plane. The geodetic height at a point is the distance from the reference ellipsoid to the point in a direction normal to the ellipsoid [9].

2.7.2 Earth Centered, Earth Fixed X, Y and Z

Earth Centered, Earth Fixed Cartesian coordinates are also used to define three dimensional positions with respect to the center of mass of the reference ellipsoid. The Z-axis points toward the North Pole. The X-axis is defined by the intersection of the plane define by the prime meridian and the equatorial plane. The Y-axis completes a right handed orthogonal system by a plane 90° east of the X-axis and its intersection with the equator [9].

2.8 Review of Related Previous Works/Researches

A paper has been produced to discuss the effects of errors to the GPS relative positioning and their modeling. Two factors basically will affect the accuracy of Global Positioning System (GPS) relative positioning which is the geometric distribution of the observed satellites and the quality of the observations. The effect of errors to GPS relative positioning differs for different types of errors which occurred during the observation. They effects in different ways for different errors.

For example, some of the errors affect the measured baseline systematically and this may produce significant scale errors and rotations. Due to the change in the error characteristics and the distribution of observed satellites, the effects of those errors may change from one survey epoch to another .The errors cannot be cancelled out in the computation completely. The effects of these errors should be modelled and eliminated for the application of high precision monitoring and engineering surveys. A case study of this paper is GPS ground-subsidence monitoring network in Venezuelan oil fields. During the survey campaigns in 1990 and 1991, the rotation of up to 6 ppm in a vertical plane was obtained. Recommendations are made for the design of monitoring schemes and control networks for large engineering projects to minimize the systematic effects of the errors [5].

Many countries produce their guidelines for testing GPS. As in Malaysia, JUPEM has produced one which describes the suggested practice for GPS equipment calibration procedures. This guideline suggests three methods of calibrating the GPS equipment which are Zero Baseline test, EDM Baseline Test and GPS Network Test. The practices might be different for different countries. For example is the one that applied only in Western Australia. These guidelines are issued under the direction of the Surveyor General. In this guideline, they suggest a practice for testing the hardware, firmware and software of GPS for surveying applications on the GPS calibration network at Curtin University. The aim is to encourage a uniform approach for the GPS to be tested. This is to provide results which are reliable validation of user systems.

The guidelines also emphasize that they do not represent legal traceability of measurement. They are specified to utilize the GPS in circumstances that follow a quality assurance approach. Not all the requirements for testing on the calibration network reflect the surveyor's normal operational usage of that system, particularly with respect to data collection rates and the number of satellites observed. The following understandings and limitations therefore apply [6]:

- These guidelines apply to GPS hardware and software systems designed for geodetic survey applications operated in differential mode where carrier phase and pseudo-range observations are recorded by the receivers.
- All equipment used in the test will be in good working order and adjustment and the GPS antenna will be oriented correctly throughout the test.
- Because approved methodologies for establishing legal traceability of length measurement for GPS do not currently exist under the Australian National Measurement

Act (1960), GPS should not be used as the sole method of measuring length in legal surveys. Surveyors using GPS for legal purposes must adhere to the requirements of the Surveyor General as the appropriate verifying authority and Chairman of the Land Surveyors Licensing Board in this State.

A study about the testing of GPS instruments of the Trimble Company in the Czech National Trigonometric Network has been conducted and investigated to evaluate and analyse the measurements obtained by two different GPS instruments of the Trimble Company. The two devices that are used in the study are Trimble 5700 and Trimble GeoExplorer CE. Trimble 5700 is a surveying apparatus while Trimble GeoExplorer CE is the data acquisition device of geographical information systems (GIS) GeoExplorer CE.

During the year 2003, the devices were employed in a test network by ten points of the Czech National Trigonometric Network. The dimension of the test network is about 8x9 km and the devices were employed repeatedly. The two devices performed in different ways such that the Trimble 5700 instrument ran repeatedly in the rapid static mode with various time periods while the GeoExplorer CE device used the phase and code measurement method in their operation.For both cases, two things were investigated which were the effects of parameter settings such as the elevation mask and the density of data recording intervals on the precision of measurements [7].

According to the book entitled Manual of Geospatial Science and Technology by John D. Bossler, John R. Jensen, Robert B. McMaster, and Chris Rizos, there are certain difficulties shared by GPS testing procedure which are stated in the followings [8];

- The magnitude of GPS biases is a function of time
- Some GPS biases are a function of geographic location
- The propagation of most GPS biases into baseline solution is a complex combination of factors such as time, location, baseline length and satellite geometry
- The quality of GPS baseline is not just a function of errors and biases, but also the length of observation session and the type of carrier phase solution
- The outcome of the testing

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 Gantt Chart

Figure 7 below shows the activities that have been planned and also the important date for the project. All of these are represented in the Gantt Chart so that the author can keep track to his own schedule and prepare for upcoming events.

No	Work/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Field work															
2	Submission of Combined Progress Report															
3	Seminar 1															
7	Poster Presentation															
8	Dissertation Report Submission															
9	Preparing for Oral presentation															
9	Oral presentation															

Figure 7: Gantt Chart

3.2 Project Methodology

Figure 8 shows the methodology of this project;

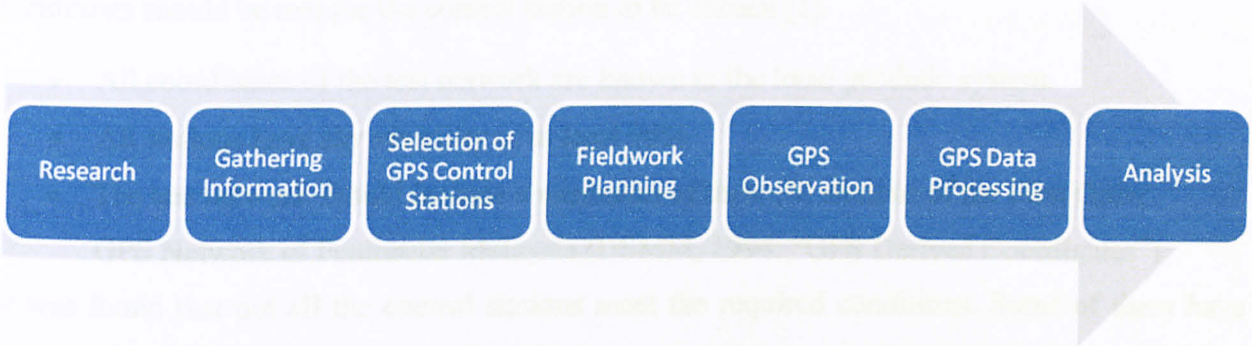

Figure 8: Project Methodology

3.3 Searching & Gathering Information

As the topic is selected and approved by FYP supervisor and FYP coordinator, the author started his project by doing search and gathering information about the topic and other related projects or works. The resources are basically from FYP supervisor, post graduate students and also the Internet. This stage is important because the author needs to understand the topic clearly before proceeding to another works. Previous Final Year Projects done by UTP students were also used as guidance to make a report and other documentation.

After the information search, the author was able to gather the information needed for the project. All the information is basically obtained from Internet, journal and books. It is important to ensure the validity of the source especially the one obtained from Internet. The information about the control stations are obtained from Department of Survey and Mapping Malaysia (DSMM) / Jabatan Ukur dan Pemetaan Malaysia (JUPEM). Another source of the information about the control stations is from the surveying consultant which is Jurukur Radian.

3.4 Selection of GPS Control Stations

Before commencing any works, the selection of control station must be done. The following conditions should be met for the control station to be chosen [1].

- All coordinates of the test network are known in the local geodetic system.
- All stations have sky visibility of at least 90%
- The test network should include a minimum of three (3) stations of the First Order GPS Network of Peninsular Malaysia (DSMM, 1994: "GPS Derived Coordinates")

It was found that not all the control stations meet the required conditions. Some of them have poor sky visibility and bad surrounding. The control stations were first identified using the map to the location and the information about the control stations. Not all the control stations have been used before so the areas surrounding some of the stations are not well-maintained. Therefore, the control stations should be visited first before selecting the one that meets the requirement.

3.5 Fieldwork Planning

There are a few important things that should be taken into consideration under the fieldwork planning. They are instrumentations that are going to be used, personnel involved in surveying and also the logistical considerations.

Instrumentations appropriate for the works must be prepared and must be checked to ensure they are in good condition. To carry out the surveying procedures, the personnel involved must be someone who knows how to use the equipment and has been trained or used to work with equipments before. They also must know and understand the surveying procedures. Under the logistical considerations, the main things are the issues such as transportation or mobilization and also the special site requirement such as getting an approval of respected party before the surveying can be done in the site or area.

3.6 GPS Surveying/Observation Procedures

The GPS Surveying must follow the procedures for Static mode positioning. During the observation, each of the GPS receivers must be connected to its designated antenna (mounted on the pillar) using the same antenna cable.

A minimum of one hour observation should be collected for each baseline once the antennas have been deployed on the stations and at least four satellites are tracked continuously during the observation.

It is important to ensure that the site conditions and time of day are good and suitable for the observation to be done. To get good results, it is suggested to test the optical plummet within the instrument tribachs and to perform the zero baselines testing before performing the GPS Network Test [1].

Figure 9 shows the GPS surveying/observation procedures applied during the fieldwork. Section 3.7.1 and 3.7.2 explain about setting up the instrument and the tripod and also centering and leveling with the optical plummet. Proper ways of doing these can reduce human errors. Refer to appendices at the back to see the various pictures taken during fieldwork.

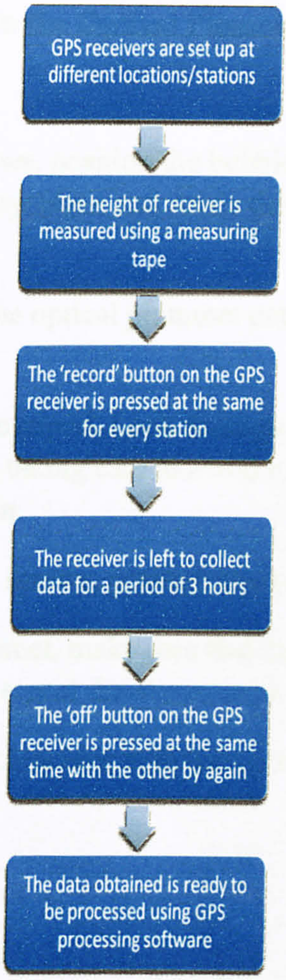

Figure 9: GPS Observation Procedures

3.6.1 Setting up the Instrument and the Tripod

1. Adjust the tripod legs to obtain a height suitable for observation when the instrument is set on the tripod.
2. Hang a plumb bob on the hook of the tripod, and center over the station on the ground coarsely. At this time, set the tripod and fix the tripod legs firmly into the ground and the plumb bob coincides with the station on the ground.
3. Adjust the length of each leg to make the tripod head as level as possible. Fix the lock screws of the tripod legs, then put the instrument on the tripod head and lock with the screws.

3.6.2 Centering and Leveling with the Optical Plummet

1. Adjust the three leveling screws, position the bubble in the center of the vial. Look through the optical plummet eyepiece and rotate the eyepiece knob until the reticulate can be seen clearly.
2. Rotate the focusing knob of the optical plummet until the measurement land mark can be seen clearly.
3. Loosen the center screw of the tripod. Look through the optical plummet, and shift the instrument base on the tripod, taking care to avoid rotating the instrument until the center mark coincides with the station.
4. By adjusting any two leveling screws, position the bubble in the center of the vial.
5. Look through the optical plummet, make sure that the land mark coincides with the center of the reticulate. If not, repeat the above steps until they are coincidence.
6. Make sure that the land mark coincides with the center of the reticulate, then, lock the instrument.

3.7 GPS Data Processing

Once the data files have been downloaded from the receivers, the data may be processed using standard baseline processing procedures. In this stage, the ambiguities must be resolved. If this is not the case for any baseline, that baseline may be excluded from the subsequent network adjustment [1]. The network adjustment procedure is as follows: [1]

- The minimally constrained network adjustment should be carried out using the computed baselines expressed in the "satellite datum" such as WGS84, or one of the ITRF datums. One of the coordinates of the test network must be held fixed and if necessary, the coordinate is transformed to the satellite datum.
- The final coordinates may need to be transformed to the established local datum system if the known coordinates of all the test network stations are provided in this datum.

3.7.1 Using PCCDU

In this section, the author will explain about the first stage of GPS data processing which is data pre-processing. All the tasks in the data pre-processing will be done by the software called PCCDU. The steps of using the software are such the following.

Step 1: Open PCCDU program and press "Connect"

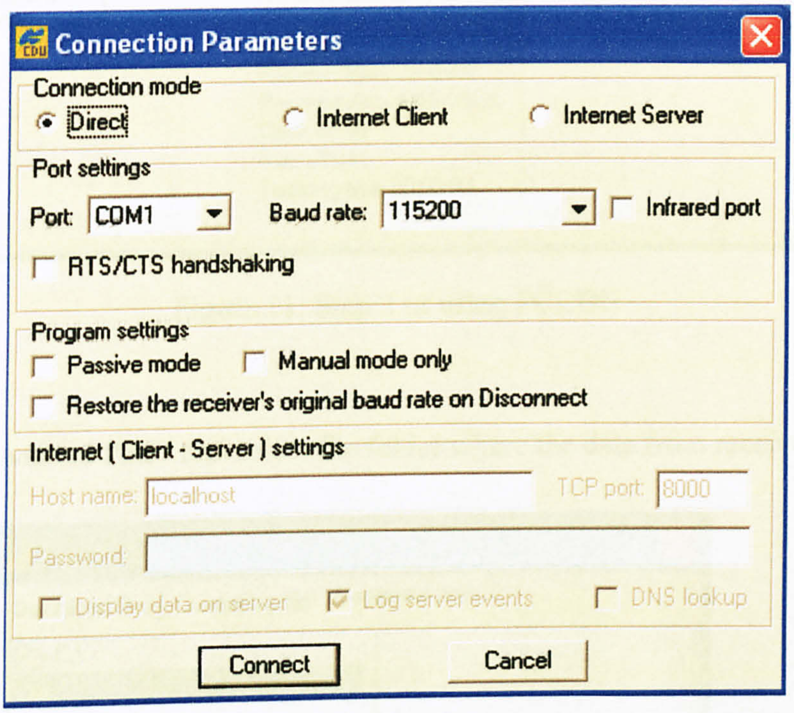

Figure 10: Step 1 of using PCCDU

Step 2: Go to the "File" menu and choose "File Manager"

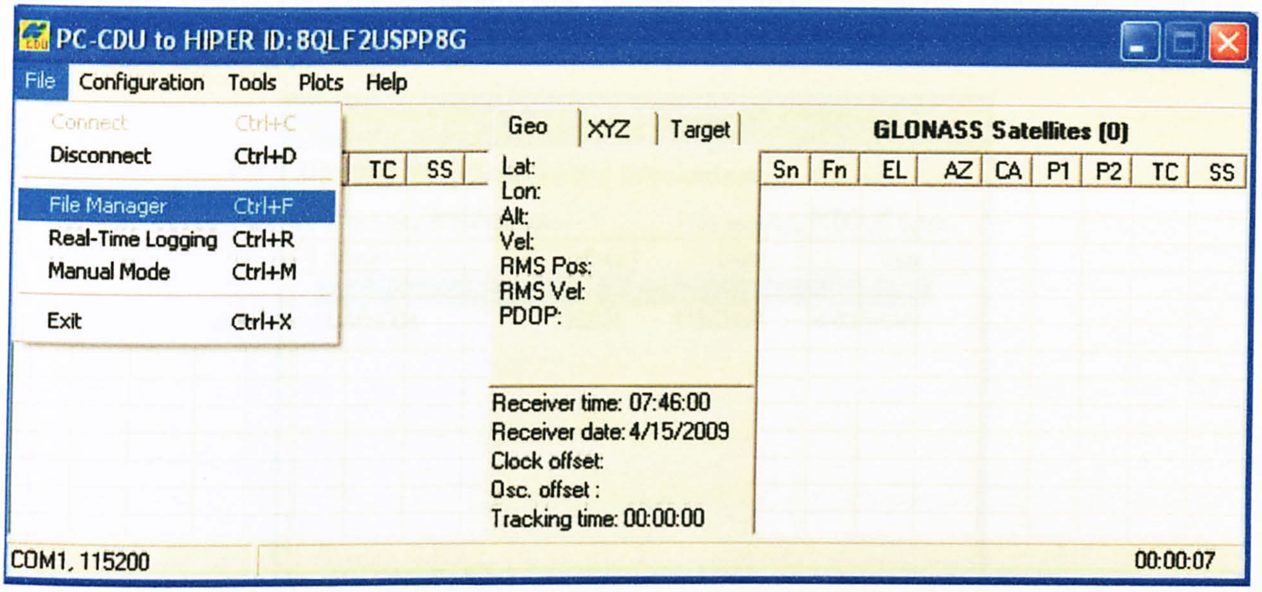

Figure 11: Step 2 of using PCCDU

Step 3: Click "Download Path" and select the folder where the data from receiver will be downloaded to.

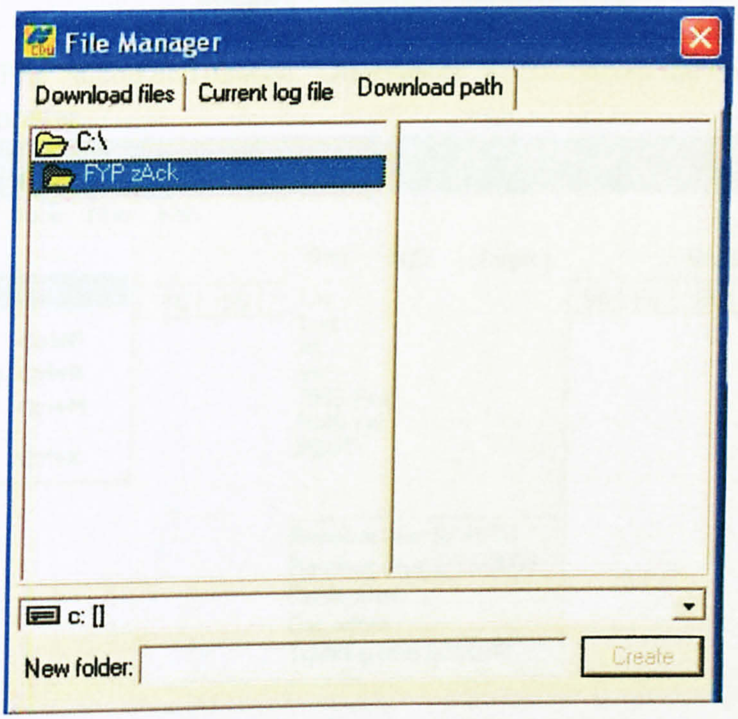

Figure 12: Step 3 of using PCCDU

Step 4: Click "Download files" and select the data from the list. Choose the data with respect to the time and date of GPS observation. Click "Download" to download the data and wait until the data finishes downloading.

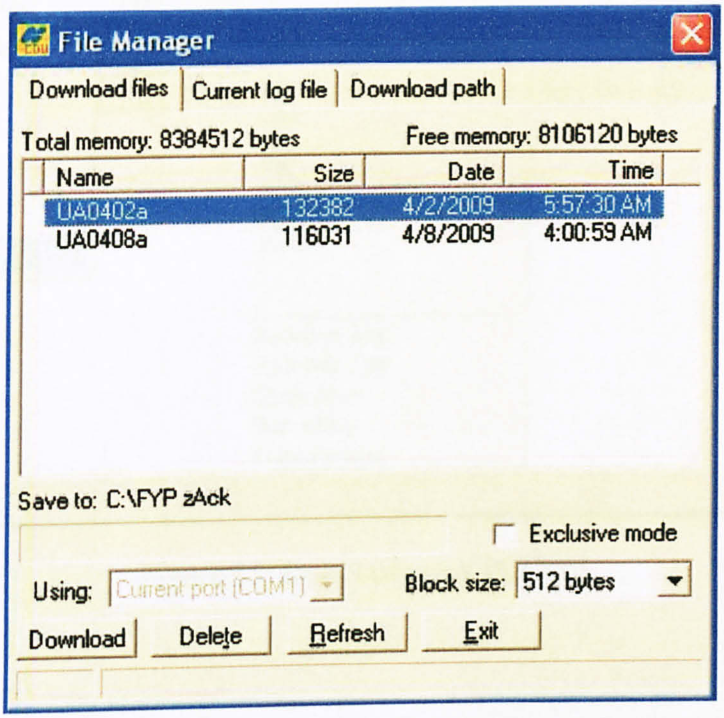

Figure 13: Step 4 of using PCCDU

Step 5: Go the "File" menu and choose "Disconnect" to disconnect the connection between the receiver and computer.

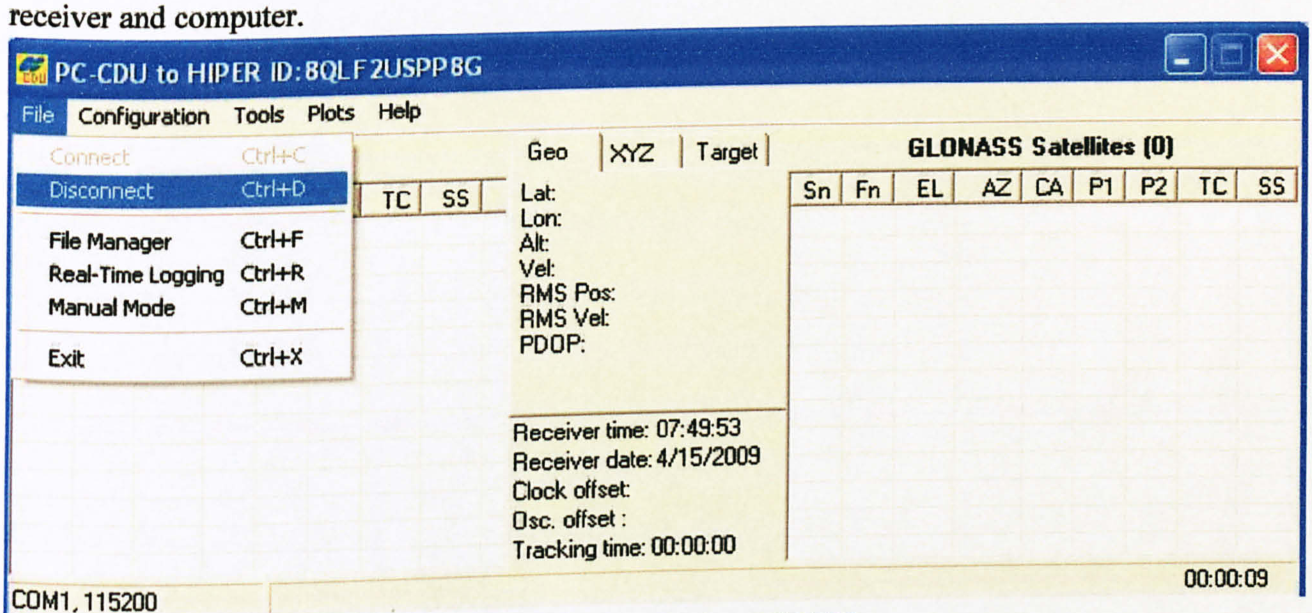

Figure 14: Step 5 of using PCCDU

Step 6: Click “File” menu again and choose to exit to close the PCCDU program.

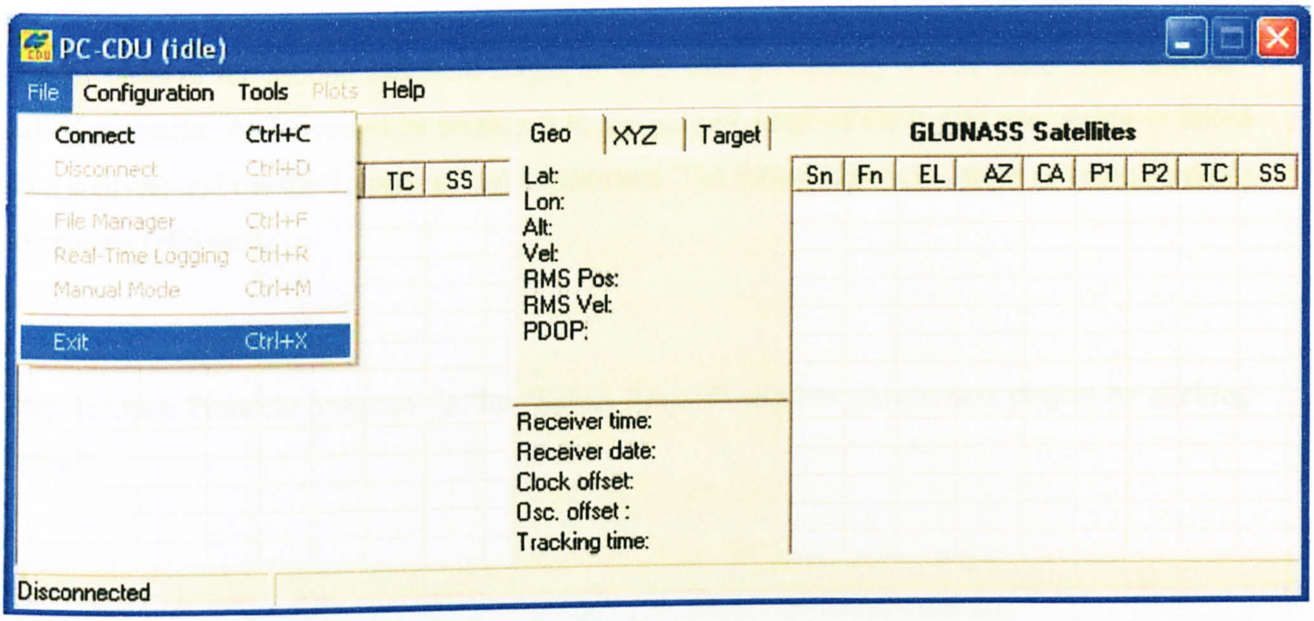

Figure 15: Step 6 of using PCCDU

3.7.2 Using Pinnacle

All the tasks of the second and third stages of GPS data processing will be done using software called Pinnacle. As informed in section 2.6, the second stage of GPS data processing is initial data analysis and the third stage is final adjustment. The following are the steps of using Pinnacle to process GPS data.

Step 1: Open Pinnacle program. In the "Select Project" window, create new project by clicking "New".

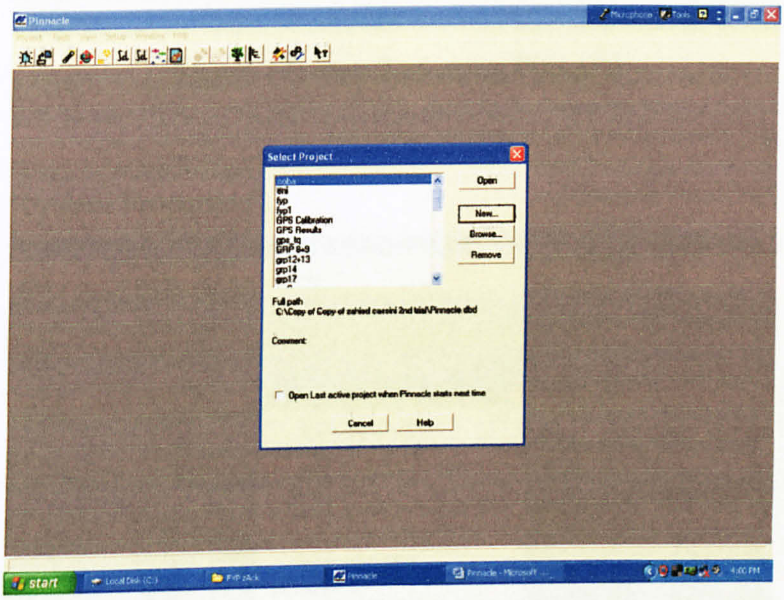

Figure 16: Step 1 of using Pinnacle

Step 2: In the “Select Directory” window, find the folder that contains the GPS data that have been downloaded from the receiver

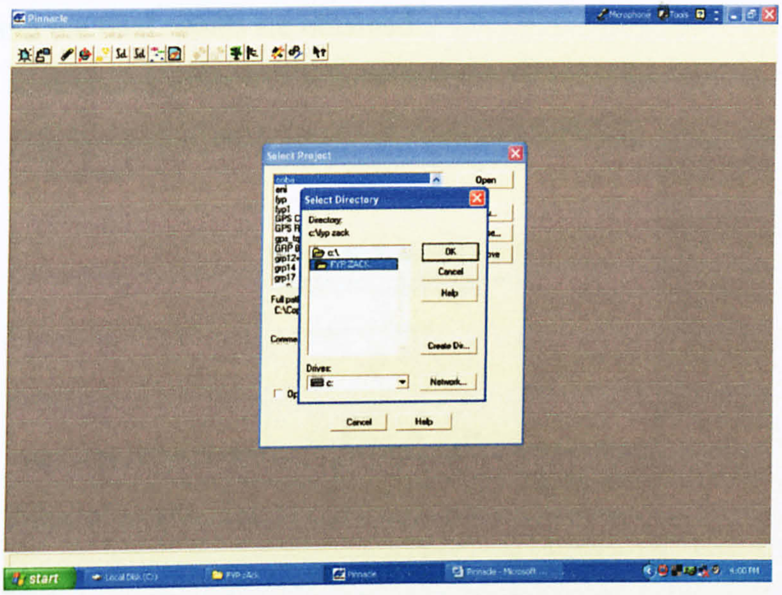

Figure 17: Step 2 of using Pinnacle

Step 3: Fill up the “Project Properties”.

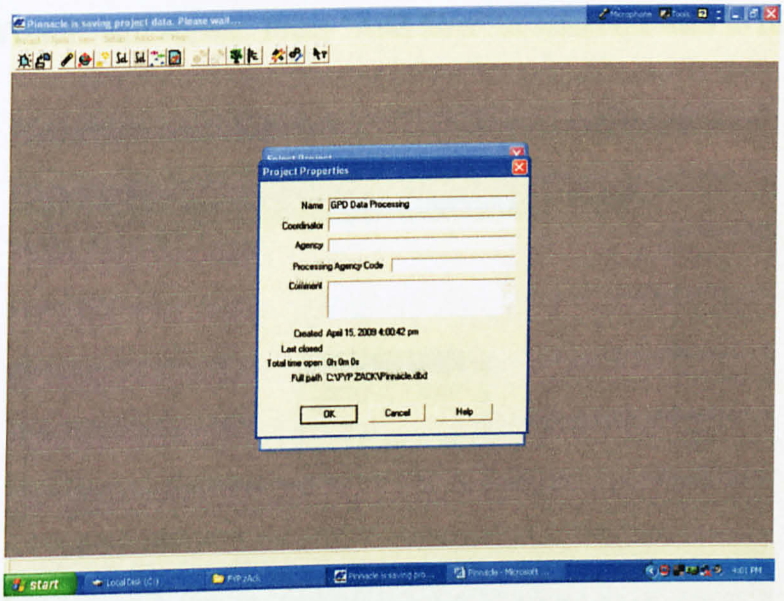

Figure 18: Step 3 of using Pinnacle

Step 4: "PINNACLE Project Wizard" window will appear and this window will guide all the remaining steps until the final results are obtained.

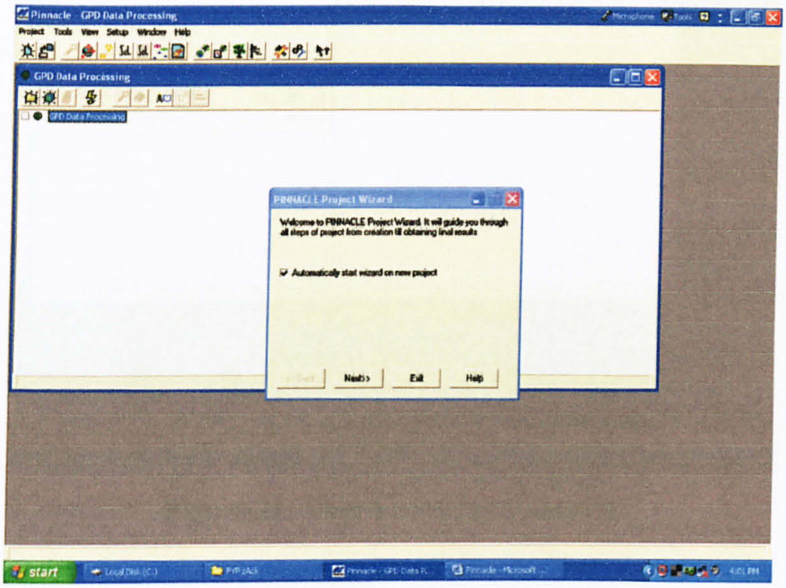

Figure 19: Step 4 of using Pinnacle

Step 5: "Import Wizard" will appear. Press "Add files" to select the data to be imported into the network.

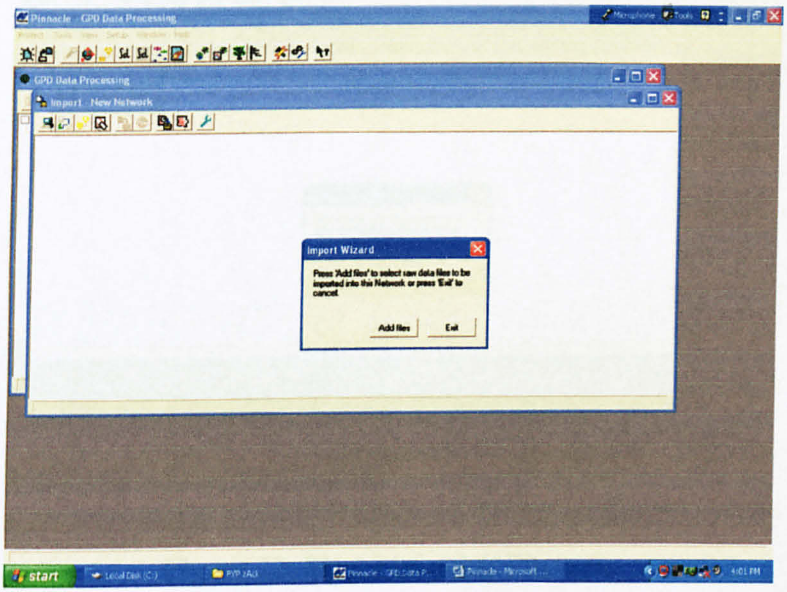

Figure 20: Step 5 of using Pinnacle

Step 6: Select all the related data and click “Open”.

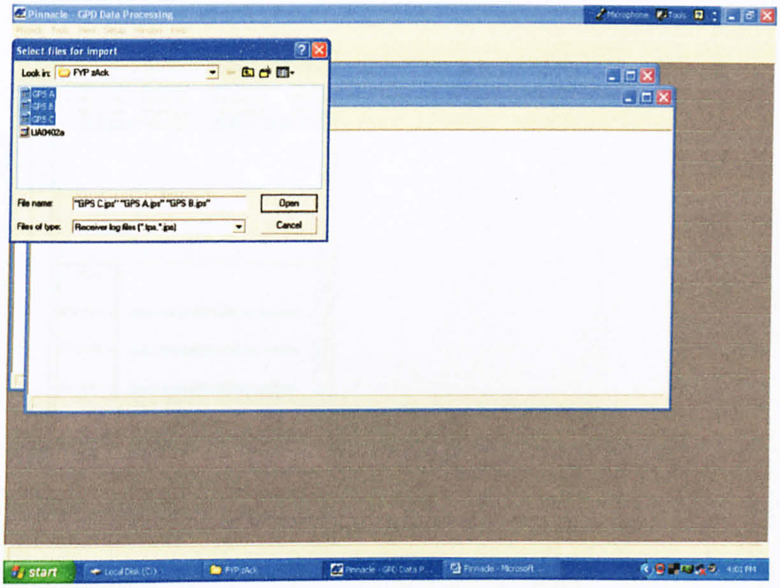

Figure 21: Step 5 of using Pinnacle

Step 7: Click “Start” to start importing the selected data. If there are more data to be imported, press “More files” to add anymore data required before clicking “Start”.

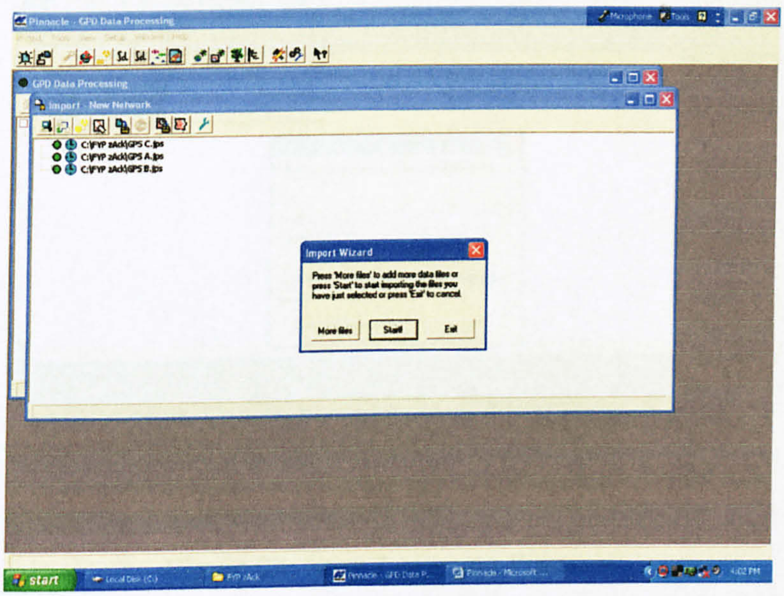

Figure 22: Step 7 of using Pinnacle

Step 8: Fill up the information regarding the antenna height and antenna type.

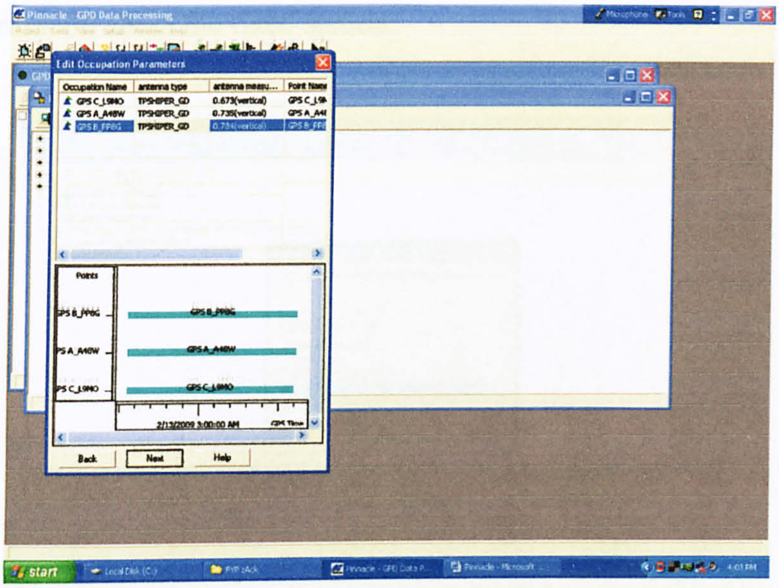

Figure 23: Step 8 of using Pinnacle

Step 9: After all data have been imported, proceed with fill up or choose the information of geoid and coordinate system for the project.

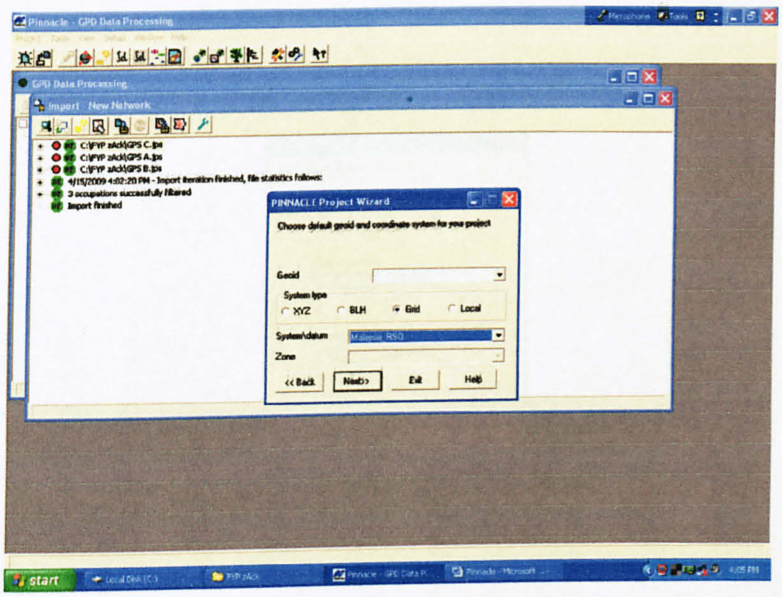

Figure 24: Step 7 of using Pinnacle

Step 10: In order to control the data and to get a good result, one station must be held fix. Fill up all necessary information about the fixed station.

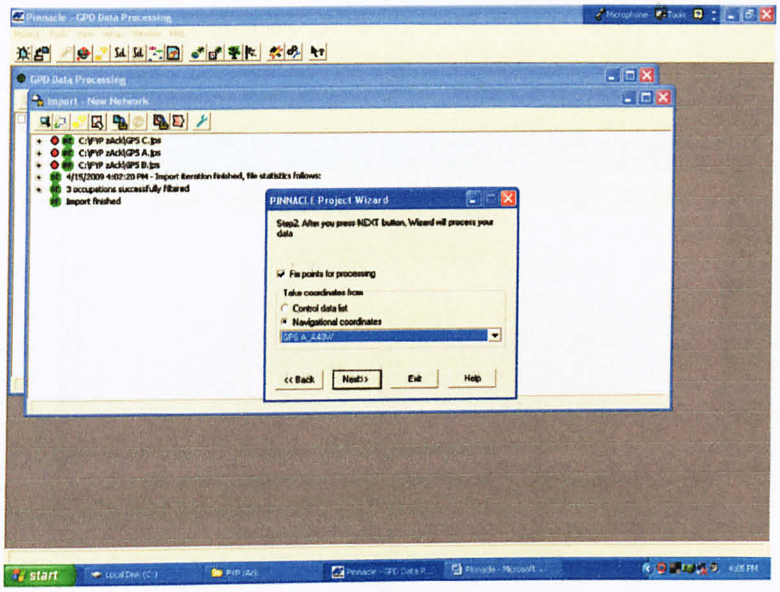

Figure 25: Step 10 of using Pinnacle

Step 11: Select the solution type of the network. This depends on the mode of GPS surveying.

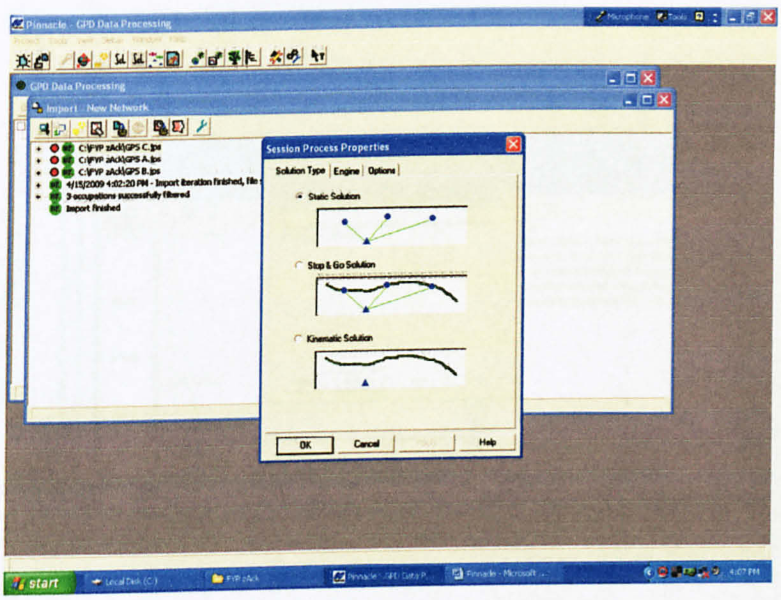

Figure 26: Step 11 of using Pinnacle

Step 12: Press "New" if there is another station to be acted as control station and press "Next" and fill up the necessary information about it. If not, press "Exit" to finish the control data part.

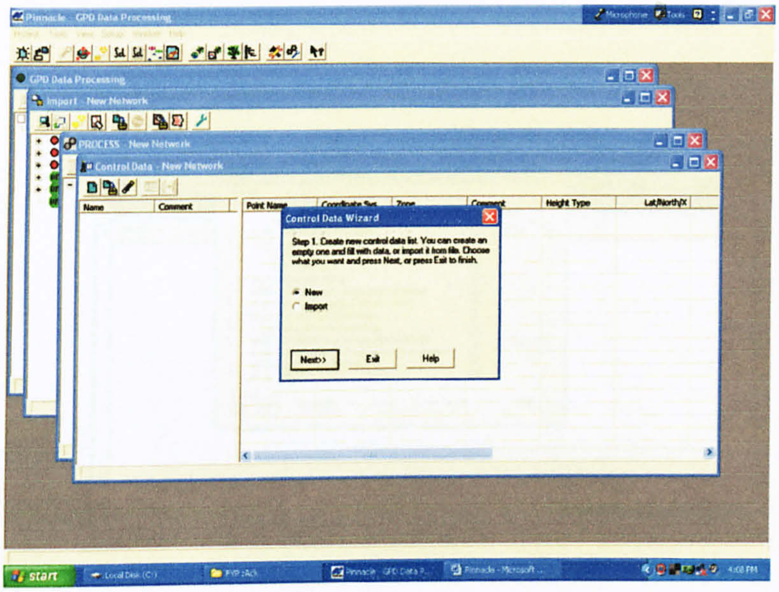

Figure 27: Step 12 of using Pinnacle

Step 13: Click "Next" to let it run the report.

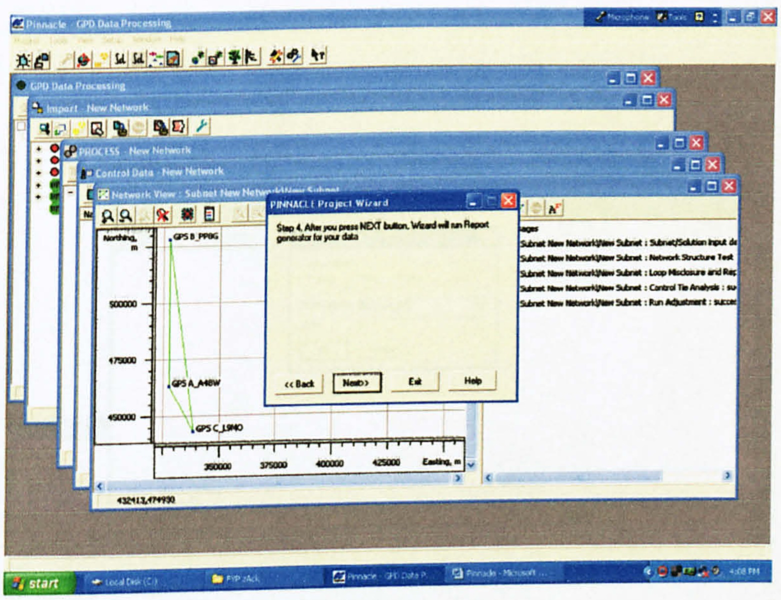

Figure 28: Step 13 of using Pinnacle

Step 14: Select all the necessary information to be included in the report.

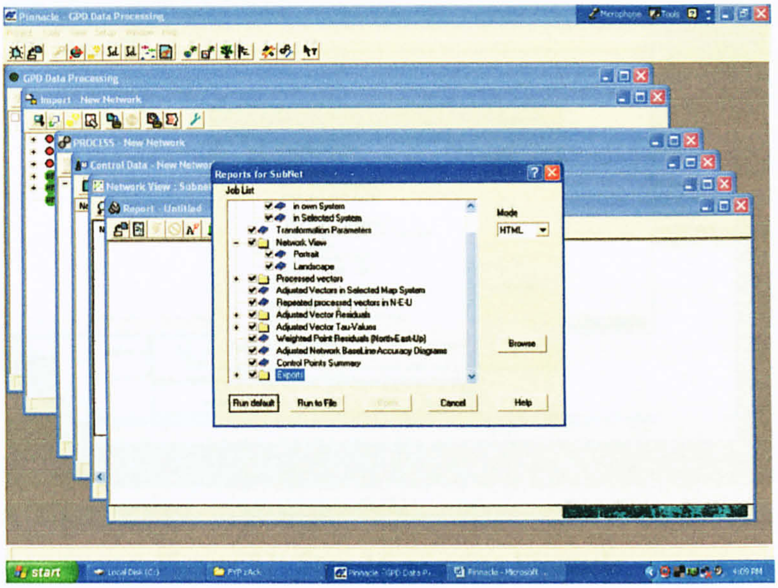

Figure 29: Step 14 of using Pinnacle

Step 15: Click "Run default" and choose the system/datum. Then, click "Ok".

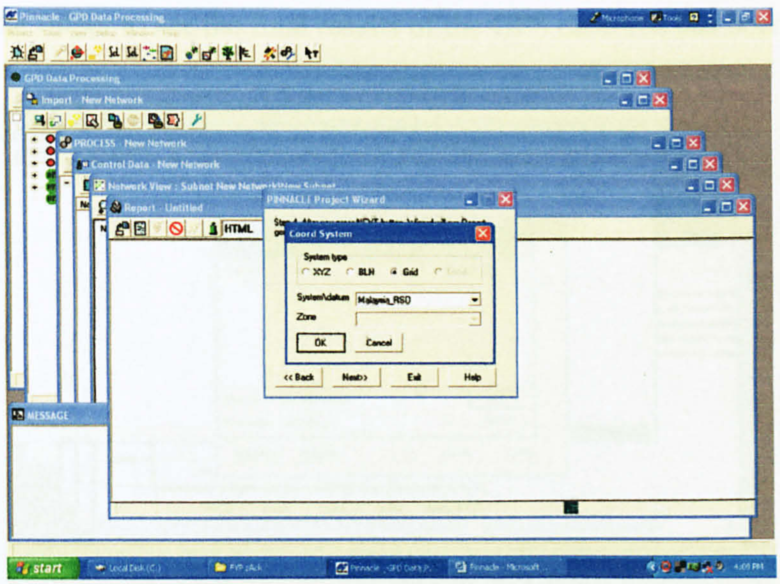

Figure 30: Step 15 of using Pinnacle

Step 16: Press "Run to file" to save the report in the folder.

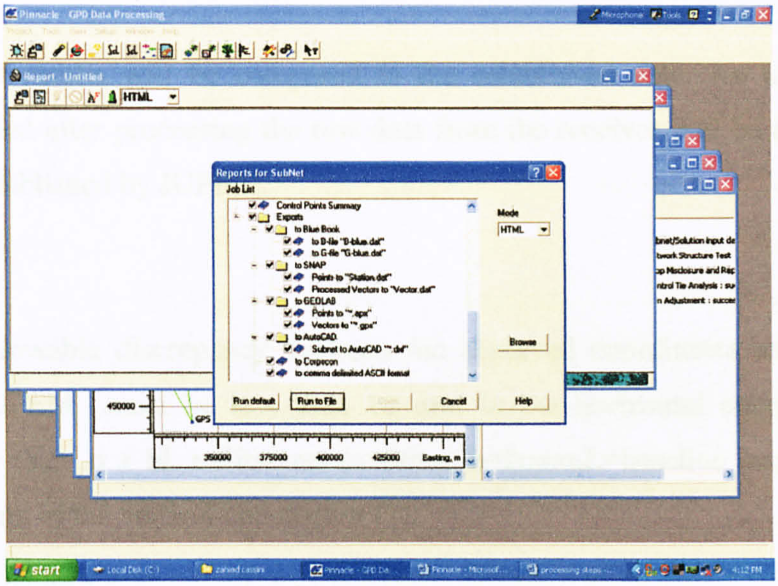

Figure 31: Step 16 of using Pinnacle

Step 17: Name the report and make sure it will be saved in respected folder. Lastly, click "Ok". Run the report in the folder to see the final results of the GPS data that has been processed.

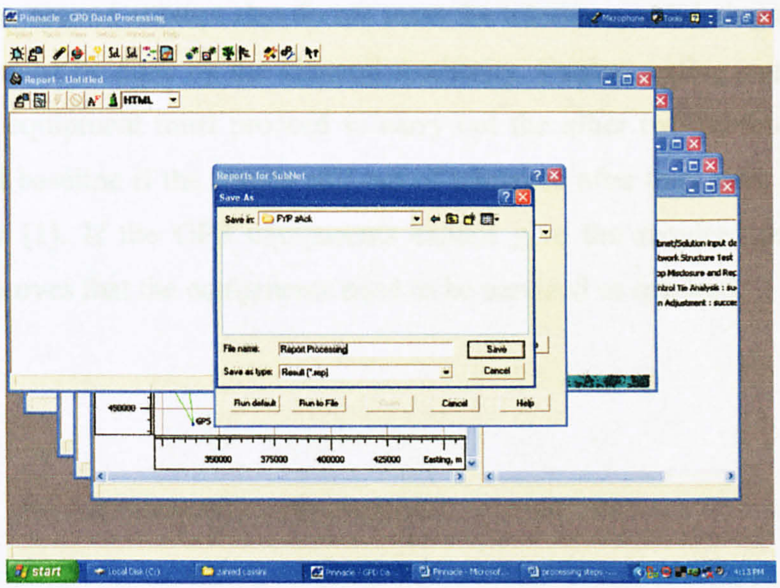

Figure 32: Step 17 of using Pinnacle

3.8 Analysis Phase

In this phase, the results will be compared to the established data. As in this project, the coordinates obtained after processing the raw data from the receiver will be compared with the the coordinates established by JUPEM.

The maximum allowable discrepancy between the observed coordinates and the coordinates established by JUPEM must be less than 10 mm in the horizontal component or relative accuracy of better than a + bL milimetres (a=5mm, b=2ppm,L=baseline length in kilometres), and less than 20 mm in the vertical component [1].

Certain measures or results will be obtained. Following the GPS Equipment Calibration Procedures stated in the GPS Cadastral Survey Guidelines published by JUPEM, recommendation for the GPS equipment will be made. If the results do not meet tolerance, it requires to be tested again using the same procedures to validate the results [1].

If the results for the second attempt also do not meet the tolerance, validating the results must be done again but it must be done by the General Authority. Further testing must be made by the GPS agent or the equipment must proceed to carry out the other two methods which are zero baseline and EDM baseline if the results still out of tolerance after they have been tested by the General Authority [1]. If the GPS equipments cannot give the required results or meet the tolerance, then it proves that the equipments need to be serviced or repaired.

3.9 Tools

For the fieldwork purposes, the following tools are used:

- Three sets of GPS instruments (Topcon HiPer Receiver). These are the main tools as the calibration is done to check the accuracy, precision and condition of them. Table 1 shows the specification of the receiver.
- Three sets of tripod and tribachs are used to support the receiver. The receiver is locked and fixed to the tripod.
- Measuring tape is used to measure the height of the receiver to the reference point.
- Camera is used to take pictures as a record and other purposes.
- For communication purposes, 4 handphones are used. These are mainly to synchronise the observation session

For processing data purposes, the following softwares and tools are used:

- PCCDU software is used to download the raw data from the receiver to the computer.
- Pinnacle software is used to process the raw data obtaining from the receiver
- Computer is used for the downloading and processing the data while RS232 serial cable is used to transfer the raw data from the receiver to the computer.

3.9.1 Powering the receiver

To turn on the receiver, push the PWR for about 0.5 second and release it. To turn it off, press the PWR key for more than 1 and less than 4 seconds (until both the STAT and the REC LEDs are off). When the receiver is ON and no satellites are tracked, the STAT LED will blink red.

3.9.2 Start/stop data recording

Holding the FN key for more than 1 second and less than 5 seconds will start/stop data recording. During the data recording the REC LED is green. If REC LED is red, it indicates the receiver has run out of memory, or there is a hardware problem.

When satellites are tracked, the STAT LED will produce one blink for each tracked satellite. The STAT LED will produce a green blink (Green light for GPS and yellow light for GLONASS). If there is no satellite signal which has energy levels above 48 db*Hz, the STAT LED will produce one additional red blink.

3.9.3 HiPer Receiver Specification

The GPS receivers that are being tested in this project are manufactured by Topcon Positioning System Inc. The following table is the specification of the receiver.

Table 1: HiPer Receiver Specification

Dimensions	**W:159 x D:172 x H:88 (mm)**			
Weight	1.65 kg			
Enclosure	Aluminum			
Antenna	Internal Micro-strip, Zero center (type) GPS/GLONASS (signal)			
Battery	Internal x 2 Li-ion, 3000 mAh, 7.4V 132 x 35 x 18 (mm) 165g (1 battery)			
Controller	External			
Color	TPS yellow			
Mounting	5/8-11			
Seals	SILICON (Molding in Color)			
Buttons	Number of buttons	PWR (Power)	FN (Function)	RESET
	3	Power ON/OFF	Start/stop logging data Switch to information mode	Hardware receiver RESET

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Fieldwork Information

Three GPS control stations involve in this project are located in Perak State. The first control station is located at Klinik Kg. Gajah, Teluk Intan for GPS A receiver, the second control station is located at SMK Clifford, Kuala Kangsar for GPS B receiver and the last one is located at Hospital Teluk Intan, Teluk Intan for GPS C receiver.

The GPS surveying for this project has been conducted on Friday, February 13, 2009. The surveying or observation started at about 9.40 a.m for all control stations and ended at about 12.55 p.m. The observation sessions took about 3 hours. The table 2 shows a summary of the operation during the observation day. Note that the times for start recording and off recording were taken by the individual performing the GPS observation.

Table 2: Summary of Fieldwork Information during Observation Day

GPS receiver	Location	Start Recording	Stop Recording	Vertical Height measured (cm)
A	Klinik Kg. Gajah, Teluk Intan	9.35 a.m	12.51 p.m	73.5
B	SMK Clifford, Kuala Kangsar	9.35 a.m	12.52 p.m	73.4
C	Hospital Teluk Intan, Teluk Intan	9.37 a.m	12.46 p.m	67.3

4.2 Results

After downloading the raw data from each receiver using the PC-CDU software, processing of the data has been done using Pinnacle software. The results of the processed data are shown in the table 3, 4, 5, 6, 7 and figure 33.

Table 3: Adjusted Coordinates in MRT94 (BLH)

Point	Coordinates		
	Latitude	Longitude	Height (m)
GPS A	4°10'56.75241"N	100°56'33.73992"E	-1.2434
GPS B	4°46'22.98774"N	100°56'21.07870"E	35.2710
GPS C	4°00'05.42876"N	101°02'31.40284"E	-5.5954

Table 4: Adjusted Coordinates in Malaysia RSO (Grid, Zone Malaysia)

Point	Coordinates		
	Northing (m)	Easting (m)	Height (m)
GPS A	462978.49449	327786.61278	-1.24342
GPS B	528281.50400	327634.23200	35.27100
GPS C	442935.58125	338746.71540	-5.59543

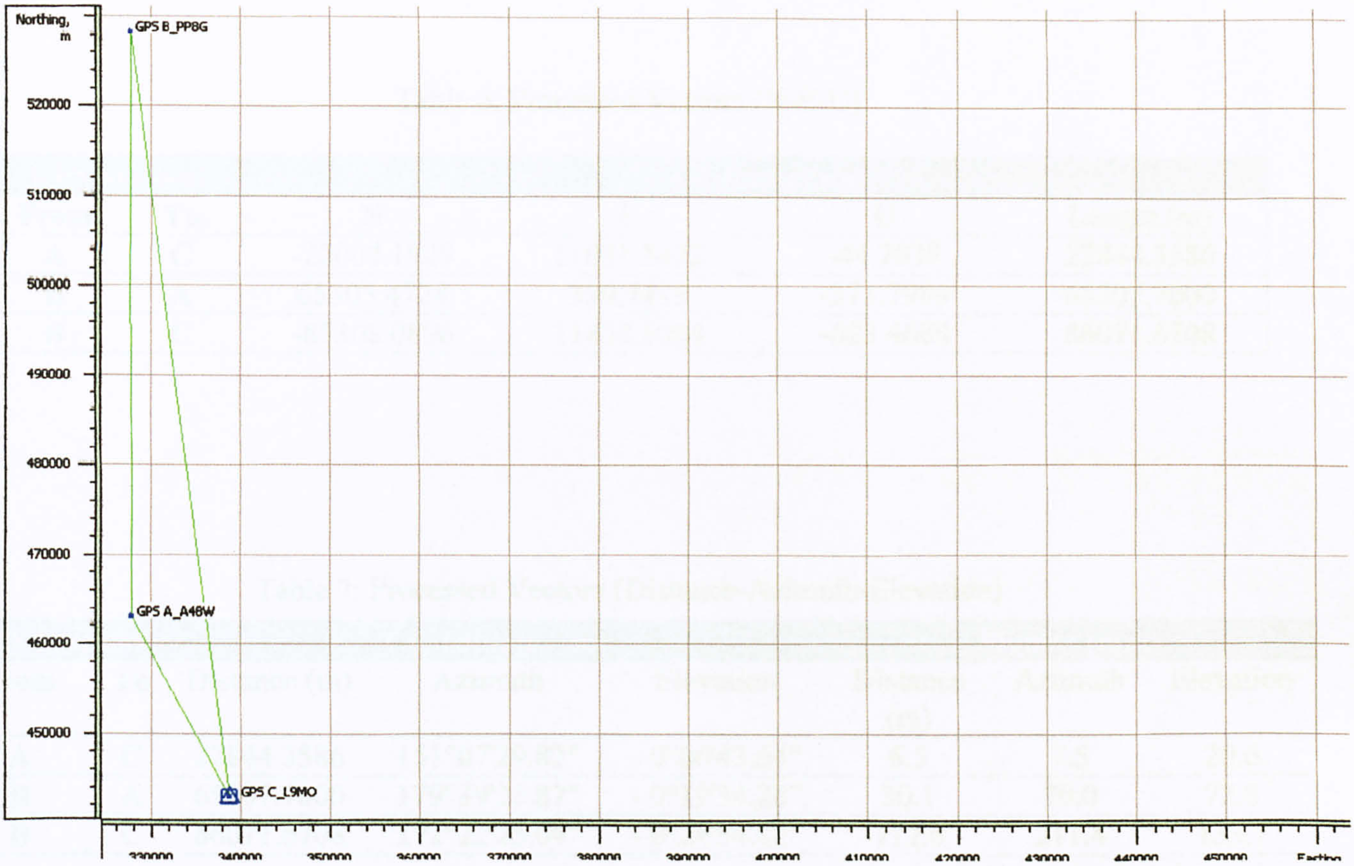

Figure 33: Network View

Table 5: Processed Vectors (X-Y-Z)

GPS Stations		Coordinates (m)			
From	To	X	Y	Z	Length (m)
A	C	-11099.4491	-705.2631	-19954.1864	22844.3586
B	A	-1344.3445	4897.0333	-65109.9646	65307.7000
B	C	-12443.9042	4191.6446	-85064.1633	86071.6708

Table 6: Processed Vectors (N-E-U)

GPS Stations		Coordinates (m)			
From	To	N	E	U	Length (m)
A	C	-20004.1929	11031.5452	-44.7039	22844.3586
B	A	65305.4728	390.7419	-371.7989	65307.7000
B	C	-85308.0896	11422.5064	-623.4688	86071.6708

Table 7: Processed Vectors (Distance-Azimuth-Elevation)

GPS Stations		Coordinates (m)			Sigmas (mm)		
From	To	Distance (m)	Azimuth	Elevation	Distance (m)	Azimuth	Elevation
A	C	22844.3586	151°07'29.82"	- 0°06'43.64"	6.5	7.5	20.6
B	A	65307.7000	179°39'25.87"	- 0°19'34.28"	30.1	70.0	72.8
B	C	86071.6708	172°22'25.04"	- 0°24'54.12"	112.6	211.4	153.7

4.3 Discussion

The coordinates that were obtained from observation will be compared with the coordinates established by JUPEM. The information regarding the coordinates established by JUPEM for the selected control stations are stated in the table 8.

Table 8: Established Coordinates of MRT94 and RSO by JUPEM

Location	GPS Reference No.	MRT94 Coordinates		RSO Coordinates	
		Latitude	Longitude	Northing (m)	Easting (m)
Klinik Kg. Gajah, Teluk Intan	P101	4°10'56.75895"N	100°56'16.15987"E	462978.694	327786.863
SMK Clifford, Kuala Kangsar	P274	4°46'22.98774"N	100°56'21.07869"E	528281.504	327634.232
Hospital Teluk Intan, Teluk Intan	GP02	4°0'5.43673"N	101°2'31.40888"E	442935.825	338746.903

GPS B which is located at SMK Clifford is made as a fixed station to control the data and network. Comparison has been made between the observed RSO coordinates and the established RSO coordinates by JUPEM for GPS A and GPS C which located at Klinik Kg. Gajah, Teluk Intan and Hospital Teluk Intan (refer table 9).

Table 9: Comparison of Coordinates in RSO Coordinates

Station	Observed Coordinates		Established Coordinates		Difference	
	Northing(m)	Easting(m)	Northing(m)	Easting(m)	Northing(m)	Easting(m)
GPS A	462978.49449	327786.61278	462978.6940	327786.8630	0.20	0.25
GPS C	442935.58125	338746.71540	442935.8250	338746.9030	0.24	0.19

From the comparison in table 9, the difference in values between the observed coordinates and the established coordinates are noticed. The difference in northing or vertical component for GPS A is 0.2 m. For the GPS C, the difference in vertical component is 0.24 m. The difference in easting or horizontal component for GPS A is 0.25 m and 0.19 m for the GPS C.

To check the condition of the receiver, three things are being considered which are horizontal component, vertical component and also the relative accuracy. As stated by JUPEM, the maximum allowable discrepancy for horizontal component must be less than 10 mm and less than 20 mm in the vertical component while for the allowable accuracy, it must be better than **a + bL** (mm) where a=5mm, b=2ppm and L=baseline length in kilometers.

The difference in Northing or vertical component between the observed and established coordinates for GPS A and GPS C are higher than 20 mm. For the horizontal component, the differences are also higher than 10 mm. This indicates that the instruments are not in good condition with respect to the allowable discrepancies of vertical and horizontal components.

Allowable accuracy is calculated by **a + bL** (a=5mm, b=2ppm, L=baseline length in kilometers). Baseline length is calculated using the formula;

$$\sqrt{[(X_1 - X_2)^2 + (Y_1 - Y_2)^2 + (Z_1 - Z_2)^2]}$$

X, Y and Z are the components of the point in Cartesian Coordinates System. Table 10 shows the X, Y and Z components for the stations which derived from the established coordinates of JUPEM.

Table 10: X, Y and Z Components of All Control Stations

Stations	Coordinates (m)		
	X	Y	Z
GPS A	-1207354.8862	6245632.413	462129.6587
GPS B	-1205959.0382	6240749.7012	527175.9579
GPS C	-1218419.1007	6244943.0687	442055.1814

The baseline lengths for lines GPS B to GPS A and GPS B to GPS C are calculated and the results of them are shown in table 11.

Table 11: Baseline Length (m) for GPS B to GPS A and GPS B to GPS C lines

Lines	Baseline length (m)
GPS B to GPS A	65244.23582
GPS B to GPS C	86130.04154

Allowable accuracy for each lines is calculated by substituting a=5mm, b=2ppm and baseline length for each lines into **a + bL.** The computed accuracy is obtained from the results of GPS data processing. Refer to table 7, the value of sigma (mm) for the distance shows the computed accuracy of the each line. The computed accuracies for lines GPS B to GPS A and GPS B to GPS C are 30.10 mm and 112.60 mm respectively. Table 12 shows the computed accuracy and allowable accuracy with respect to the lines and distances.

Table 12: Distance, Computed Accuracy and Allowable Accuracy

Lines	Distance (km)	Computed Accuracy (mm)	Allowable Accuracy (mm)
GPS B to GPS A	65.244	30.10	135.49
GPS B to GPS C	86.130	112.60	177.26

The computed accuracy is lower than the allowable accuracy for each line. This indicates that the instruments tested are in good condition. However, analysis that has been made before showed that for the vertical and horizontal components for each station are not within the allowable discrepancy. The results do not meet all the requirements. So, it can be concluded that the GPS instruments are not in good condition.

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Three things are considered to check the condition of GPS instruments using GPS Network Test method which are;

1) Allowable discrepancy for horizontal component must be less than 20 mm
2) Allowable discrepancy for vertical component must be less than 10 mm
3) Computed accuracy must be less than the allowable accuracy.

The GPS instruments are in good condition when all the requirements are met. In the case of GPS instruments in UTP, the results obtained after conducting the calibration procedure using GPS Network Test are such the following;

1) Coordinates difference values for each components are not within the allowable discrepancies
2) Computed accuracies for each line are within the allowable accuracies.

The results show that the GPS instruments are not in best condition because they do not meet all the requirements. They are not suitable for high accuracy application of GPS works and should be sent for services before doing such kind of works. However, those instruments can still be used in laboratory or learning purposes in UTP.

This project achieves its objective as the calibration procedures to the GPS instruments have successfully been done and the accuracy of the GPS receivers have been computed and checked.

5.2 Recommendation

For the upcoming works, it is recommended to use the other of GPS processing softwares so that a comparison between the results obtained by different softwares can be made. By this, the performance between the softwares will also be evaluated. To validate the results, the instruments should be calibrated using the other methods of calibration.

Some of the location of GPS control stations established by JUPEM is not suitable for the GPS surveying due to the condition of the site. Information regarding the current condition control stations must be updated by JUPEM so that the surveyor of the researcher will know whether the control stations can be used or not. If possible, the data about the control stations should be made available on the Internet to make it easier to access.

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APPENDICES

Figure 34: The arrangement of instruments with GPS control stations

Figure 35: Receiver before it is facing to the north

Figure 37: Receiver is facing to the north

Figure 38: Centering the bolt mounted on top of the GPS control station

Figure 39: Centering the bubble before attaching the receiver on top of the tribrach

WGS84 COORDINATES FOR GPS STATION IN PENINSULAR MALAYSIA
DEPARTMENT OF SURVEY AND MAPPING MALAYSIA

STATE LOCATION OF GPS STATIONS	GPS STATIONS REFERENCE NUMBER	WGS84 COORDINATES LATITUDE DD MM SS	 LONGITUDE DD MM SS	ELLIPSOIDAL HEIGHTS (h) metre
PAHANG BKT BESAR, TEMERLOH	TG15	3 23 35.71992	102 14 11.26270	434.907
PAHANG STAPS TG GELANG, KUANTAN	TG24	3 58 30.90724	103 25 40.13307	6.676
PAHANG BANDAR JERANTUT	TG25	3 56 8.39606	102 21 52.93255	148.849
PAHANG GUNUNG IRAU, C. HIGHLANDS	TG57	4 31 44.39419	101 21 54.70814	2104.837
PAHANG G. SWETHENHAM, C. H'LANDS	TG58	4 34 38.21620	101 27 51.88937	1957.294
PAHANG G. CHANTEK, C. HIGHLANDS	TG59	4 27 42.05087	101 25 30.01561	1797.841
PERAK HOSP DAERAH TK. INTAN	GP02	4 0 4.53046	101 2 26.45558	-3.355
PERAK SMK SUNGKAI, B. PADANG	GP07	3 59 31.11920	101 18 36.89519	37.285
PERAK JPS KUALA SLIM, B. PADANG	GP29	3 46 55.29076	101 19 28.93761	11.466
PERAK KG. BEHRANG, B. PADANG	GP30	3 47 56.63117	101 31 15.75661	155.390
PERAK KLINIK SELEKOH, B. DATOK	GP82	3 54 9.99888	100 47 21.17286	-5.829
PERAK KLINIK KG. GAJAH	P101	4 10 55.80327	100 56 28.83789	0.126
PERAK JPS PANTAI REMIS, L-MATANG	P102	4 26 28.81498	100 37 44.92886	-3.767
PERAK PPH SENOI PRAAQ, BIDOR	P201	4 8 42.37967	101 17 1.67761	52.910

Dpn. sek. keb. Hutan Melintang HM01 3 53 39.34198 100 55 37.8482~~8~~ 2 -4.~~7091~~ 3106 (2.221) orth.

WGS84 COORDINATES FOR GPS STATION IN PENINSULAR MALAYSIA
DEPARTMENT OF SURVEY AND MAPPING MALAYSIA

STATE LOCATION OF GPS STATIONS	GPS STATIONS REFERENCE NUMBER	WGS84 COORDINATES LATITUDE DD MM SS	 LONGITUDE DD MM SS	ELLIPSOIDAL HEIGHTS (h) metre
PERAK SMK KAMPAR, KAMPAR	P202	4 17 24.65540	101 9 13.95714	33.501
PERAK SMK GOPENG, GOPENG	P203	4 27 58.76992	101 9 50.16517	52.613
PERAK TMN SRI RAPAT, IPOH	P204	4 34 23.28452	101 6 11.89938	32.414
PERAK TMN PARIT JAYA, PARIT	P205	4 29 20.17628	100 55 9.22428	24.622
PERAK SRK BOTA KIRI, PARIT	P207	4 21 26.72035	100 52 18.34652	8.895
PERAK BUKIT NAGA, SITIAWAN	P209	4 35 9.37471	100 42 22.63265	315.338
PERAK AIRPORT SITIAWAN	P210	4 13 33.05285	100 42 1.42795	-1.279
PERAK PULAU PANGKOR, MANJUNG	P211	4 13 55.31657	100 32 46.96836	-4.946
PERAK KLINIK T.HITAM, K.K'GSAR	P270	4 43 45.13708	101 6 17.61442	76.005
PERAK RPS LEGAP, K.KANGSAR	P271	4 56 26.21557	101 15 8.42242	149.641
PERAK FELDA LASAH, K.KANGSAR	P272	4 55 33.81190	101 4 20.76834	71.837
PERAK LOJI AIR SG.SIPUT, K.K	P273	4 49 20.35990	101 4 27.68745	112.382
PERAK SMK CHILFORD, K.KANGSAR	P274	4 46 21.87686	100 56 16.15987	35.271
PERAK KLINIK SAUK, K.KANGSAR	P275	4 55 50.13131	100 55 32.47576	69.693

LOCAL GEODETIC AND PLANE COORDINATES DERIVED FROM WGS84 COORDINATES SURVEY AND MAPPING DEPARTMENT MALAYSIA

STATE DISTRICT LOCATION OF GPS	GPS REF NO	MRT 94 COORDINATES		RSO COORDINATES		STATE CASSINI COORDINATES	
		LATITUDE DD MM SS	LONGITUDE DD MM SS	NORTHING metre	EASTING metre	NORTHING metre	EASTING metre
PAHANG CAMERON HIGHLAND G.SWETHENHAM	TG58	4 34 39.26542	101 27 57.05364	506477.914	385981.377	95895.663	-107655.841
PAHANG CAMERON HIGHLAND GUNUNG CHANTEK	TG59	4 27 43.07039	101 25 35.15924	493709.204	381571.312	83116.557	-112047.768
PERAK TELUK INTAN HOSP DAERAH	GP02	4 0 5.43673	101 2 31.40888	442935.825	338746.903	38599.917	25015.788
PERAK BATANG PADANG SMK.SUNGKAI	GP07	3 59 32.01798	101 18 41.97465	441813.313	368677.541	37586.563	54951.342
PERAK BATANG PADANG JPS KUALA SLIM	GP29	3 46 56.13390	101 19 34.01992	418593.598	370213.338	14370.318	56571.085
PERAK BATANG PADANG KG.BEHRANG	GP30	3 47 57.47500	101 31 20.93150	420415.587	392025.987	16269.944	78376.132
PERAK BAGAN DATOK KLINIK SELEKOH	GP82	3 54 10.88398	100 47 26.00664	432145.301	310780.508	27706.320	-2910.154
PERAK TELUK INTAN KLINIK KG.GAJAH	P101	4 10 56.75895	100 56 33.74800	462978.694	327786.863	58602.752	13981.274
PERAK LARUT-MATANG JPS PANTAI REMIS	P102	4 26 29.84431	100 37 49.69762	491770.550	293242.003	87263.384	-20672.997
PERAK BIDOR PPH SENOI PRAAQ	P201	4 8 43.31931	101 17 6.74749	458753.703	365792.701	54518.219	52004.283
PERAK KAMPAR SMK.KAMPAR	P202	4 17 25.63562	101 9 18.96872	474840.935	351421.353	70553.983	37572.277
PERAK GOPENG SMK.GOPENG	P203	4 27 59.79633	101 9 55.18460	494313.246	352602.058	90032.814	38679.805

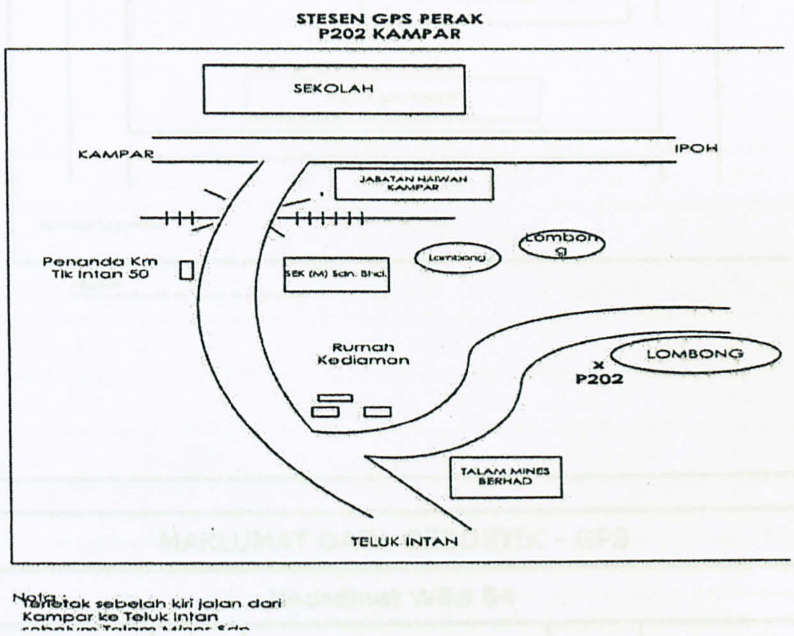
LOCAL GEODETIC AND PLANE COORDINATES DERIVED FROM WGS84 COORDINATES SURVEY AND MAPPING DEPARTMENT MALAYSIA

STATE / DISTRICT / LOCATION OF GPS	GPS REF NO	MRT 94 COORDINATES		RSO COORDINATES		STATE CASSINI COORDINATES	
		LATITUDE DD MM SS	LONGITUDE DD MM SS	NORTHING metre	EASTING metre	NORTHING metre	EASTING metre
PERAK IPOH TAMAN SRI RAPAT	P204	4 34 24.34010	106 6 16.89224	506145.661	345914.214	101841.287	31946.349
PERAK PARIT TAMAN PARIT JAYA	P205	4 29 21.21294	100 55 14.12952	496908.534	325455.496	92525.289	11521.471
PERAK BOTA SRK.BOTA KIRI	P207	4 21 27.72332	100 52 23.22723	482385.876	320133.691	77981.681	6254.813
PERAK LARUT-MATANG BUKIT NAGA	P209	4 35 10.44038	100 42 27.44035	507725.225	301867.575	103251.486	-12109.019
PERAK MANJUNG AIRPORT SITIAWAN	P210	4 13 34.02439	100 42 6.22615	467909.620	301054.898	63432.930	-12769.087
PERAK MANJUNG PULAU PANGKOR	P211	4 13 56.29254	100 32 51.69472	468663.053	283958.392	64121.143	-29867.820
PERAK KUALA KANGSAR KLINIK T\HITAM	P270	4 43 46.23309	101 8 22.62634	523388.766	349847.099	119101.686	35813.462
PERAK KUALA KANGSAR RPS LEGAP	P271	4 56 27.36498	101 16 13.49919	546715.737	364428.863	142488.929	50306.973
PERAK KUALA KANGSAR FELDA LASAH	P272	4 55 34.96079	101 4 25.75273	545179.401	342625.179	140867.295	28506.532
PERAK KUALA KANGSAR JPS SG.SIPUT	P273	4 49 21.48146	101 4 32.67107	533708.837	342798.183	129395.715	28724.198
PERAK KUALA KANGSAR SMK.CHILFORD	P274	4 46 22.98774	100 56 21.07869	528281.504	327634.232	123909.161	13579.255
PERAK KUALA KANGSAR KLINIK SAUK	P275	4 55 51.28382	100 55 37.39157	545739.583	326353.331	141364.051	12230.626

MAKLUMAT DATA GEODETIK - GPS							
Stesen	**Koordinat WGS 84**						**Catitan**
P202	Latitud	1.96o	Longitud	1.96o	Tinggi El.(m)	1.96o	
	4° 17' 24.6115"		101° 9' 13.995510"		33.9850		
	Koordinat MRT						
	Latitud	1.96o	Longitud	1.96o		1.96o	
	Koordinat RSO						
	Utara (m)	1.96o	Timur (m)	1.96o		1.96o	
	474845.2090		351227.1120				

Lakaran: P202.jpg

Lokasi bagi stesen P202 di SMK KAMPAR, PERAK
P202

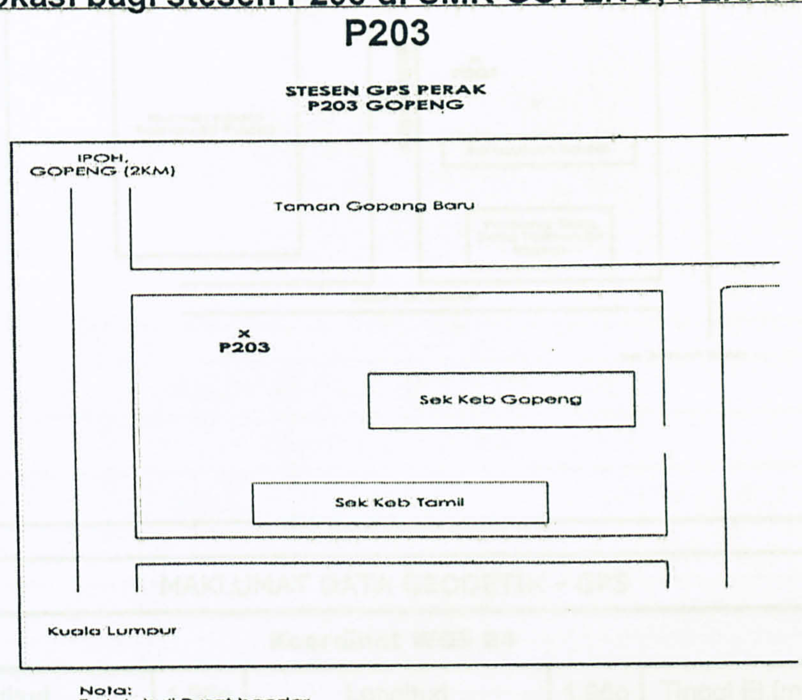


MAKLUMAT DATA GEODETIK - GPS							
Stesen	**Koordinat WGS 84**						**Catitan**
	Latitud	1.96o	Longitud	1.96o	Tinggi El.(m)	1.96o	
	4° 27' 58.725850"		101° 9' 50.203580"		53.1060		
	Koordinat MRT						
	Latitud	1.96o	Longitud	1.96o		1.96o	

P203	Koordinat RSO						
	Utara (m)	1.96o	Timur (m)	1.96o		1.96o	
	494317.5430		352407.7590				

Lakaran: P203.jpg

Lokasi bagi stesen P203 di SMK GOPENG, PERAK



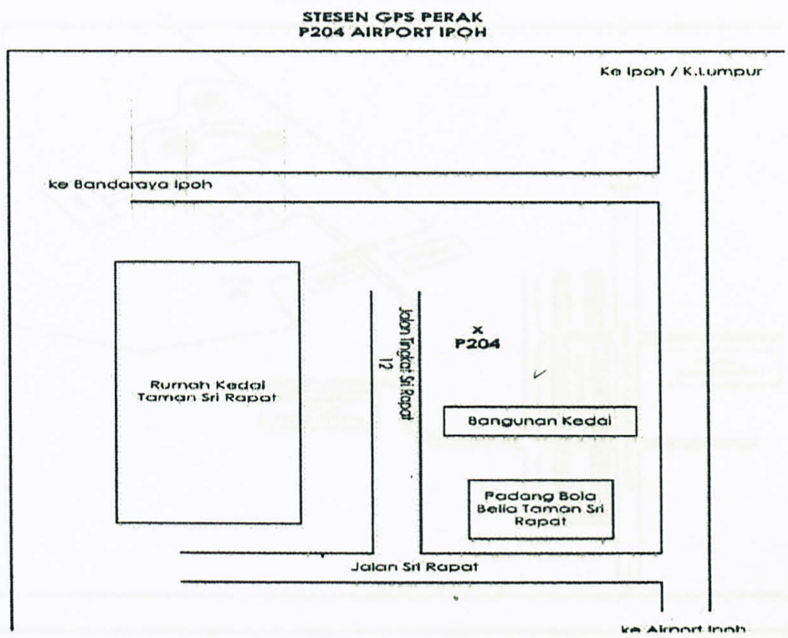
MAKLUMAT DATA GEODETIK - GPS

Stesen	Koordinat WGS 84						Catitan
P204	Latitud	1.96o	Longitud	1.96o	Tinggi El.(m)	1.96o	
	4° 34' 23.240330"		101° 6' 11.937750"		32.90		
	Koordinat MRT						
	Latitud	1.96o	Longitud	1.96o		1.96o	
	Koordinat RSO						
	Utara (m)	1.96o	Timur (m)	1.96o		1.96o	
	506149.9510		345719.8720				

Lakaran: P204.jpg

Lokasi bagi stesen P204 di TMN SRI RAPAT, PERAK

P204

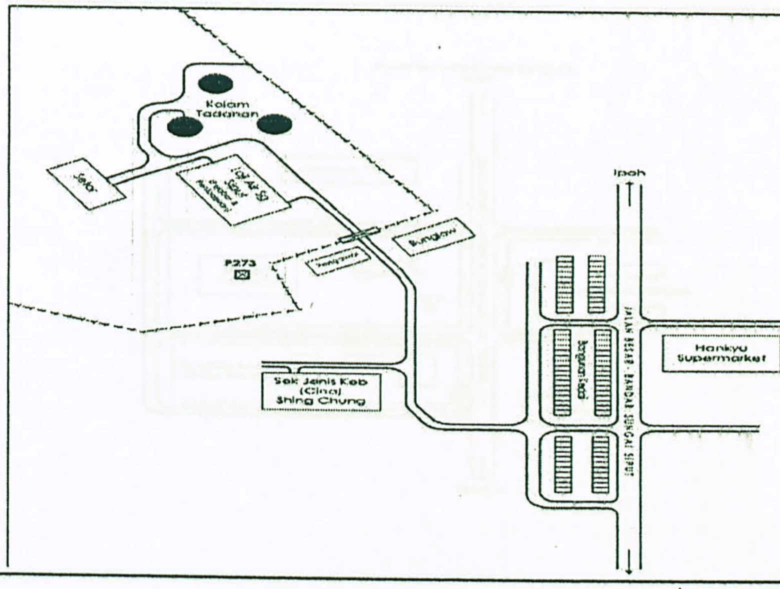


MAKLUMAT DATA GEODETIK - GPS							
Stesen	**Koordinat WGS 84**						**Catitan**
P273	Latitud	1.96o	Longitud	1.96o	Tinggi El.(m)	1.96o	
	4° 49' 20.315460"		101° 4' 27.725760"		112.8560		
	Koordinat MRT						
	Latitud	1.96o	Longitud	1.96o		1.96o	
	Koordinat RSO						
	Utara (m)	1.96o	Timur (m)	1.96o		1.96o	
	533713.15		342603.7550				

Lakaran: P273.jpg

Lokasi bagi stesen P273 di LOJI AIR SG.SIPUT, PERAK
P273

STESEN GPS NEGERI PERAK
P273(Bandar Sg Siput)

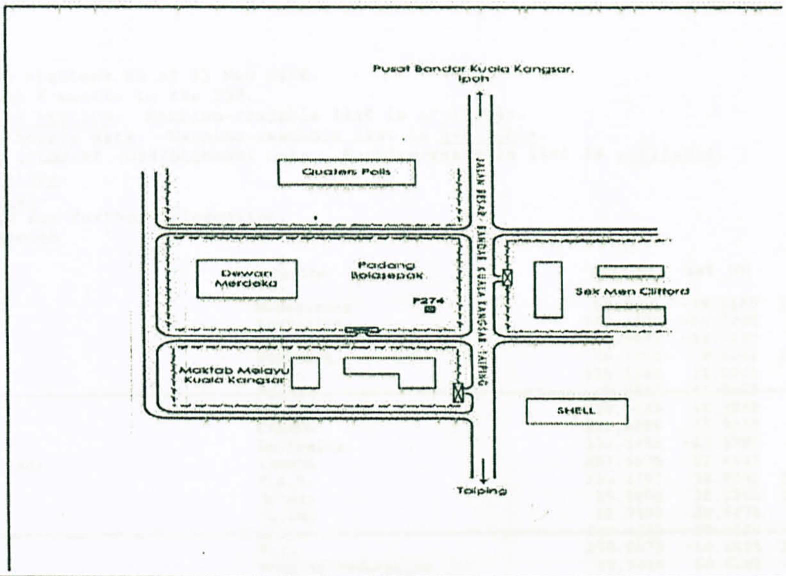


MAKLUMAT DATA GEODETIK - GPS							
Stesen	**Koordinat WGS 84**						**Catitan**
P274	Latitud	1.96o	Longitud	1.96o	Tinggi El.(m)	1.96o	
	4° 46' 21.832470"		100° 56' 16.197910"		35.7360		
	Koordinat MRT						
	Latitud	1.96o	Longitud	1.96o		1.96o	
	Koordinat RSO						
	Utara (m)	1.96o	Timur (m)	1.96o		1.96o	
	528285.7690		327439.79				

Lakaran: P274.jpg

<u>Lokasi bagi stesen P274 di SMK CHILFORD, PERAK</u>
P274

STESEN GPS NEGERI PERAK
P274(Bandar Kuala Kangsar)



IGS Tracking Network
ABOUT IGS ORGANIZATION FAQs FTP ARCHIVES WEBSITE INDEX

IGS Stations

414 stations and 367 active stations as of 13 Nov 2008.
N Designates a site newer than 6 months to the IGS.
R Designates a Reference Frame station. Machine-readable list is available.
H Designates a site offering hourly data. Machine-readable list is available.
I Designates a site offering IGLOS-PP (GPS/GLONASS) data. Machine-readable list is available.
View a list of former IGS sites.
View a list of proposed sites.
Click on any 4-character id for further information.
Dormant sites are ~~lined through~~

	id	City	Location	lon (E)	lat (N)	ht (m)	Agency
H	abpo	Antananarivo	Madagascar	47.2292	-19.0183	1552.9923	JPL
N	adel	Salisbury	Australia	138.6473	-34.7290	38.2000	NGA
N	ade2	Salisbury	Australia	138.6473	-34.7290	38.2000	NGA
HI	adis	Addis Ababa	ETHIOPIA	38.7663	9.0351	2439.1540	BKG
H	aira	Aira	Japan	130.5996	31.8241	314.6400	GSI
	~~ajac~~	~~Ajaccio~~	~~France~~	~~8.7626~~	~~41.9275~~	~~98.8000~~	~~IGN~~
H	albh	Victoria	Canada	236.5126	48.3898	32.0000	GSC
RH	algo	ALGONQUIN PARK	CANADA	281.9286	45.9588	202.0000	NRCan / GSD
RHI	alic	Alice Springs	Australia	133.8855	-23.6701	603.2650	GA
R	alrt	Alert (Ellesmere Island)	Canada	297.6595	82.4943	78.1100	NRCan/GSD
RH	amc2	Colorado Springs	U.S.A.	255.4754	38.8031	1912.4898	USNO
	ammn	Amman	Jordan	35.8800	32.0300	1055.8300	RJGC
HI	ankr	Ankara	Turkey	32.7586	39.8875	974.8000	BKG and GCM
	~~antc~~	~~Los Angeles~~	~~Chile~~	~~288.4679~~	~~-37.3387~~	~~745.4000~~	~~G2~~
H	areq	Arequipa	Peru	288.5072	-16.4655	2488.9226	JPL
RH	arti	Arti	Russian Federation	58.5605	56.4298	247.5110	RDAAC-IRIS
R	~~asc1~~	~~Ascension Island~~	~~Ascension Island~~	~~345.5879~~	~~-7.9512~~	~~105.0000~~	~~JPL~~
R	~~aspa~~	~~Pago Pago~~	~~U.S.A.~~	~~189.2776~~	~~-14.3261~~	~~53.6620~~	~~ASDOG~~
H	auck	Whangaparaoa Peninsula	New Zealand	174.8344	-36.6028	132.0000	GNS
	azu1	Azusa	USA	242.1000	34.1300	144.7500	UNAVCO
H	baie	BAIE COMEAU	CANADA	291.7367	49.1868	27.4800	NRCan/GFZ
	~~bake~~	~~BAKER LAKE~~	~~CANADA~~	~~263.9977~~	~~64.3178~~	~~4.4100~~	~~NRCan/GFZ~~
	bako	Cibinong	Indonesia	106.8500	-6.4900	158.1800	BAKOSURTANAL
H	ban2	Bangalore	India	77.5116	13.0343	831.9000	GFZ
H	barh	Bar Harbor	USA	291.7783	44.3950	7.4000	NOAA-NGS
H	bdos	Bridgetown	Barbados	300.3909	13.0880	-38.6370	NOAA-NGS
N	bhr1	Manama	Bahrain	50.6081	26.2091	-13.9000	NGA
N	bhr2	Manama	Bahrain	50.6081	26.2091	-13.9000	NGA
R	~~bili~~	~~Bilibino~~	~~Russian Federation~~	~~166.4380~~	~~68.0761~~	~~456.2380~~	~~RDAAC-IRIS~~
	bill	Temecula	USA	242.9400	33.5800	470.0500	UNAVCO
R	bjfs	Fangshan	China	115.8925	39.6086	87.4130	NGCC
	blyt	Blythe	USA	245.2900	33.6100	85.9000	USGS
I	bogi	Borowa Gora	Poland	21.0352	52.4750	139.9000	IGiK
H	bogt	Bogota	Colombia	285.9191	4.6401	2576.7782	JPL
RH	borl	Borowiec	Poland	17.0668	52.1002	124.0000	SRC PAS
	bran	Burbank	USA	241.7200	34.1800	246.2500	USGS
R	braz	Brasilia	Brazil	312.1222	-15.9474	1106.0413	DGFI
H	brew	Brewster	USA	240.3174	48.1315	238.6273	JPL
H	brft	Eusebio	Brazil	321.5745	-3.8774	21.7000	NOAA-NGS
H	brmu	Bermuda	UK	295.3037	32.3704	-11.6120	NOAA-NGS
HI	brst	Brest	France	355.5034	48.3805	65.8000	IGN
RH	brus	Brussels	Belgium	4.3592	50.7978	149.7000	ROB
HI	bucu	Bucuresti	Romania	26.1257	44.4639	143.2000	BKG
N	bue1	San Martin	Argentina	301.4807	-34.5737	48.8000	NGA
N	bue2	San Martin	Argentina	301.4807	-34.5737	48.8000	NGA
HI	bzrg	Bolzano - Bozen	Italy	11.3368	46.4990	328.8000	GpsBZ
RH	cagl	Cagliari	Italy	8.9728	39.1359	238.4000	ASI
	cags	Gatineau	Canada	284.1927	45.5850	235.0000	NRCan/GSD
HI	cagz	Capoterra	Italy	8.9728	39.1359	238.0000	DIST-Cagliari
RH	cas1	Casey	Antarctica	110.5197	-66.2834	22.5500	GA
	casa	Mammoth Lakes	USA	241.1034	37.6446	2390.4416	LVO
H	ccjm	Ogasawara	Japan	142.1846	27.0956	208.8300	GSI
RH	cedu	Ceduna	Australia	133.8098	-31.8667	144.8021	GA
	cfag	Caucete	Argentina	291.7674	-31.6022	703.0000	CERI
H	chan	CHANGCHUN	CHINA	125.4433	43.7905	268.3000	CHO
RH	chat	Waitangi	New Zealand	183.4342	-43.9558	58.0000	GNS
	chil	San Gabriel Mountains	USA	241.9700	34.3300	1567.5200	USGS
RH	chpi	Cachoeira Paulista	Brazil	315.0148	-22.6871	617.5951	JPL
H	chum	Chumysh	Kazakhstan	74.7511	42.9985	716.3321	JPL
RH	chur	CHURCHILL	CANADA	265.9113	58.7591	-18.9000	NRCan/GSD
H	chwk	Chilliwack	Canada	237.9916	49.1566	170.0000	GSC
H	cic1	Ensenada	Mexico	243.3342	31.8707	64.3245	JPL
	cit1	Pasadena	USA	241.8700	34.1400	215.3600	USGS
	clar	Claremont	USA	242.2900	34.1100	373.6400	USGS
	cmp9	Sylmar	USA	241.5900	34.3500	1138.0200	USGS
H	cnmr	Saipan	USA	145.7431	15.2297	64.3990	NOAA-NGS
RH	coco	Cocos (Keeling) Island	Australia	96.8339	-12.1883	-35.2212	GA
H	conc	Concepcion	Chile	286.9750	-36.8428	200.0270	BKG
RHI	conz	Concepcion	Chile	286.9745	-36.8438	181.2000	BKG
	copo	Copiapo	Chile	289.6618	-27.3845	479.2000	G2
R	~~cord~~	~~Cordoba~~	~~Argentina~~	~~295.5300~~	~~-31.5284~~	~~747.0654~~	~~JPL~~
	~~coso~~	~~Coso Junction~~	~~USA~~	~~242.1911~~	~~35.9823~~	~~1455.1622~~	~~USGS~~
	coyq	Coyhaique	Chile	288.1079	-45.5143	476.0000	G2
	~~crao~~	~~Simeiz~~	~~Ukraine~~	~~33.9906~~	~~44.4129~~	~~387.5545~~	~~UNAVCO~~
	crfp	Yucaipa	USA	242.9000	34.0400	688.8300	USGS
RH	cro1	Christiansted	U.S. Virgin Islands (USA)	295.4157	17.7569	-31.9558	JPL
	csn1	Northridge	USA	241.4800	34.2500	261.4400	USGS
N H	cusv	Patumwan	Thailand	100.5339	13.7359	76.0600	DUT
RH	daej	Daejeon	Korea	127.3745	36.3994	117.0370	KASI
	~~dakr~~	~~Dakar~~	~~Senegal~~	~~342.5352~~	~~14.6850~~	~~63.1000~~	~~GFZ~~
I	~~[illegible]~~	~~Darwin~~	~~Australia~~	~~131.1327~~	~~-12.8438~~	~~125.1970~~	~~GA~~
RHI	darw	Darwin	Australia	131.1327	-12.8438	125.2000	GA
RH	dav1	Davis	Antarctica	77.9726	-68.5773	44.5000	GA
HI	~~[illegible]~~	~~Davis~~	~~Antarctica~~	~~77.9726~~	~~-68.5773~~	~~44.5000~~	~~GA~~

RH	dgar	Diego Garcia Island	U.K. Territory	72.3702	-7.2697	-64.7455	JPL
	dhlg	Durmid Hill	USA	244.2100	33.3900	-83.0500	SIO
H1	dlft	Delft	Netherlands	4.3876	51.9860	, 74.3000	TUD/DEOS
	drag	Metzoki dragot	Israel	35.3924	31.5929	120.3000	GSM
RH	drao	Penticton	Canada	240.3750	49.3226	542.0000	GSC
RH	dubo	Lac du Bonnet	Canada	264.1338	50.2588	251.0000	GSC
I	dubr	Dubrovnik	Croatia	18.1104	42.6500	454.3000	CGI
	duml	Antarctic base of "Dumont d'Urville"	Antarctica	140.0019	-66.6651	-1.4000	ENS/CNRS
H	dund	Dunedin	New Zealand	170.5972	-45.8837	389.0000	GNS
	dyr2	Diyarbakir	Turkey	40.2764	37.9157	500.0000	UNV-JPL-GCM
H	ebre	Roquetes	Spain	0.4924	40.8209	107.9000	ICC
N	eil1	Fairbanks	USA	212.8870	64.6879	176.6000	NGA
N	eil2	Fairbanks	USA	212.8870	64.6879	176.6000	NGA
H1	eprt	Eastport	USA	293.0079	44.9087	30.9880	NOAA-NGS
	escu	Escuminac	Canada	295.2013	47.0734	-16.0200	NRCan/GSD
	esti	Esteli	Nicaragua	273.6379	13.0995	852.6700	INETER
H1	faa1	Faaa	Tahiti, French Polynesia	210.3857	-17.5553	12.3500	ESOC
H	fair	Fairbanks	USA	212.5008	64.9780	319.1771	JPL
	~~fale~~	~~Faleolo~~	~~Samoa~~	~~188.0005~~	~~-13.8322~~	~~48.0000~~	~~GNS~~
H1	ffmj	Frankfurt / Main	Germany	8.6650	50.0906	178.2000	BKG
RH	flin	CFS Flin Flon	Canada	258.0220	54.7256	320.0000	GSC
H1	ganp	Ganovce	Slovakia	20.3229	49.0347	745.2000	GKU
H	geno	Genova	Italy	8.9211	44.4194	137.0000	ASI
RH	glps	Puerto Ayora	Ecuador	269.6963	-0.7430	1.7946	JPL
RH1	glsv	Kiev	Ukraine	30.4967	50.3642	226.8000	MAO
	gmas	Maspalomas	Spain	344.5324	27.7648	195.4000	JAXA
	gmsd	Nakatane town	Japan	131.0156	30.5564	142.3645	JAXA
RH	gode	Greenbelt	USA	283.1732	39.0217	14.5046	JPL
H1	godz	Greenbelt	USA	283.1732	39.0217	14.5090	JPL
H	gol2	Goldstone	USA	243.1107	35.4252	986.6779	JPL
RH	gold	Goldstone	USA	243.1107	35.4252	986.6779	JPL
H1	gope	Ondrejov	Czech Republic	14.7856	49.9137	592.6000	RIGTC GOP
	goug	Gough Island	dependent territory of the U.K.	350.1333	-40.3488	81.3000	AWI
RH	gras	Caussols	France	6.9206	43.7547	1320.3000	CNES
H	graz	Graz	Austria	15.4935	47.0671	538.3000	BEV
RH	guam	Dededo	Guam	144.8683	13.5893	201.9220	JPL
R	guao	URUMQI	CHINA	87.1773	43.4711	2049.2000	UAO
	~~gust~~	~~Guatemala City~~	~~Guatemala~~	~~269.4798~~	~~14.5904~~	~~1519.8680~~	~~IGN-GT~~
H	guug	Mangilao	USA	144.8027	13.4332	134.7100	NOAA-NGS
	~~haly~~	~~Halat Ammar~~	~~Saudi Arabia~~	~~36.0999~~	~~29.1389~~	~~861.6765~~	~~MIT~~
RH	harb	Pretoria	Republic of South Africa	27.7075	-25.8869	1555.0000	CNES
H	harv	Vandenberg AFB	USA	239.3179	34.4694	14.9941	NASA/JPL
H	hers	Hailsham	England	0.3362	50.8673	76.4990	NSGF
H1	hert	Hailsham	England	0.3344	50.8675	83.3000	NSGF
	hilo	Hilo	USA	204.9473	19.7192	29.0000	PGF
RH	hlfx	HALIFAX	CANADA	296.3887	44.6835	3.1200	NRCan/GFZ
R	hnlc	Honolulu	USA	202.1355	21.3033	22.0000	PGPSF
H	hnpt	Cambridge	USA	283.8690	38.5880	-27.4000	NOAA-NGS
RH	hob2	Hobart	Australia	147.4387	-42.8047	41.1263	GA
RH1	hofn	Hoefn	Iceland	344.8132	64.2673	82.5000	BKG
H	holb	Holberg	Canada	231.8650	50.6404	560.0000	GSC
R	holm	Ulukhaktuk, formerly Holman (Victoria Island)	Canada	242.2391	70.7364	39.5000	NRCan/GSD
	holp	Hollydale	USA	241.8318	33.9245	-6.7077	USGS
RH	hrao	Krugersdorp	South Africa	27.6870	-25.8901	1414.1603	HRAO
N	hrm1	Hermitage	United Kingdom	358.7161	51.4537	163.1000	NGA
N	hrm2	Hermitage	United Kingdom	358.7161	51.4537	163.1000	NGA
H1	hueg	Huegelheim	Germany	7.5962	47.8339	278.4000	BKG
RH	hyde	Hyderabad (located in central part of India)	INDIA	78.5509	17.4173	441.6800	NGRI,HYDERABAD
H	ieng	Torino	Italy	7.6394	45.0151	316.5000	I.N.RI.M.
RH	iisc	Bangalore	India	77.5704	13.0212	843.7145	JPL
	ineg	Aguascalientes	Mexico	257.7158	21.8562	1888.5680	INEGI
	invk	Inuvik	Canada	226.4730	68.3062	46.3600	NRCan/GSD
	iqqe	Iquique	Chile	289.8683	-20.2735	38.9000	G2
I	irkj	Irkutsk	RUSSIA	104.3162	52.2190	502.1000	VNIIFTRI
H	irkm	Irkutsk	Russia	104.3162	52.2190	502.3170	RDAAC-IMVP-JPL-LDEO
R	irkt	Irkutsk	Russia	104.3162	52.2190	503.3816	DEOS-DUT
RH	ispa	Easter Island	Chile	250.6556	-27.1250	112.4948	JPL
H	ista	Istanbul	Turkey	29.0193	41.1044	147.2000	BKG
R	~~jab1~~	~~Jabiru~~	~~Australia~~	~~132.8939~~	~~-12.6588~~	~~82.1140~~	~~GA~~
H1	joz2	Jozefoslaw	Poland	21.0323	52.0978	152.5000	WUT
RH	joze	JOZEFOSLAW near WARSAW	POLAND	21.0332	52.0863	141.0000	WUT
H	jplm	Pasadena	USA	241.8268	34.2048	423.9843	JPL
RH	karr	Karratha	Australia	117.0972	-20.9814	109.2463	GA
RH	kely	Kangerlussuaq	Greenland	309.0552	66.9874	229.8064	JPL
RH	kerg	Port aux Francais	Kerguelen Islands	70.2555	-49.3515	74.0583	CNES
	kgni	KOGANEI	JAPAN	139.4881	35.7103	123.5000	RAAG-KSRC
I	khaj	Khabarovsk	RUSSIA	135.0462	48.5215	130.6000	VNIIFTRI
	~~khar~~	~~Kharkiv~~	~~Ukraine~~	~~36.2390~~	~~50.0051~~	~~201.0000~~	~~MAO~~
H1	kir0	Kiruna	Sweden	21.0602	67.8776	497.9000	LMV
H	kiru	Kiruna	Sweden	20.9684	67.8573	391.1000	ESOC
RH	kit3	Kitab	Uzbekistan	66.8800	39.1400	643.0000	GFZ Potsdam
RH	kokb	Kokee Park, Waimea,	USA	200.3351	22.1263	1167.5216	JPL
H1	kosg	Kootwijk	Netherlands	5.8096	52.1784	97.9000	DUT
	koug	Koumac	New Caledonia	164.2873	-20.5587	84.0000	DITTT
H1	kour	Kourou	French Guyana	307.1940	5.2522	-25.5700	ESOC
	ksmv	KASHIMA	JAPAN	140.6577	35.9554	57.9000	RAAG-KSRC
	kstu	Krasnoyarsk	Russia	92.7900	55.9900	210.0000	GFZ
R	kunm	Kunming	China	102.7972	25.0295	1986.2000	JPL
H	kuuj	KUUJJUARAPIK	CANADA	282.2546	55.2784	-0.4800	NRCan/GFZ
	kwj1	Kwajalein Atoll	Marshall Islands	167.7302	8.7222	38.0000	JPL
R	~~lae1~~	~~Lae~~	~~Papua New Guinea~~	~~146.9932~~	~~-6.6737~~	~~140.3500~~	~~RSES~~
H1	lama	Olsztyn	Poland	20.6699	53.8924	187.0000	UWM_OLSZTYN
	lbch	Long Beach	USA	241.8000	33.7900	-27.5600	USGS
	leep	Hollywood	USA	241.6782	34.1346	485.0517	USGS
H1	leij	Leipzig	Germany	12.3741	51.3540	178.4000	BKG
	~~lhas~~	~~LHASA~~	~~China~~	~~91.1040~~	~~29.6573~~	~~3622.0000~~	~~BKG~~
RH1	lhaz	Lhasa	China	91.1040	29.6573	3622.0000	BKG
	long	Irwindale	USA	242.0000	34.1100	74.2900	USGS
RH	lpgs	La Plata	Argentina	302.0677	-34.9067	29.9000	GFZ
	lroc	La Rochelle	France	358.7807	46.1589	57.9000	CLDG
RH	mac1	MacQuarie Island, Sub-Antarctic	Southern Ocean	158.9358	-54.4995	-6.6900	GA
H	mad2	Robledo	Spain	355.7503	40.4292	829.5000	JPL
RH	madr	Robledo	Spain	355.7503	40.4292	829.5000	JPL
	~~mag0~~	~~Magadan~~	~~Russian Federation~~	~~150.7700~~	~~59.5758~~	~~361.9266~~	~~RDAAC-IRIS~~
N H1	mal2	Malindi	Kenya	40.1940	-2.9960	-20.4000	ESOC
	~~male~~	~~Male Airport~~	~~Republic of Maldives~~	~~73.5263~~	~~4.1887~~	~~-92.0000~~	~~PGPSF~~
RH	mana	Managua	Nicaragua	273.7513	12.1491	170.0000	INETER
H1	mar6	Maartsbo	Sweden	17.2585	60.5951	75.4000	LMV
H1	mars	Marseille	France	5.3538	43.2788	61.8000	IGN
RH1	mas1	Maspalomas	Spain	344.3667	27.7637	197.3000	ESOC
H1	mat1	MATERA	ITALY	16.7045	40.6491	534.5000	ASI
RH	mate	Matera	Italy	16.7045	40.6491	535.6000	ASI
	maui	Haleakala, Maui	USA	203.7430	20.7067	3062.0000	PGPSF
RH	maw1	Mawson	Antarctica	62.8707	-67.6048	59.1840	GA
RH	mbar	Mbarara	Uganda	30.7379	-0.6015	1337.6533	JPL
	~~mcil~~	~~Ogasawara~~	~~Japan~~	~~153.9787~~	~~24.2901~~	~~35.6600~~	~~GSI~~
RH	mcm4	Ross Island	Antarctica	166.6693	-77.8383	98.0222	JPL
RH	mdo1	Fort Davis	USA	255.9850	30.6805	2004.4761	JPL
R I	mdvj	Mendeleevo	Russia	37.2145	56.0215	257.4000	IMVP
	mdvo	Mendeleevo, Moscow Region	Russia	37.2236	56.0275	254.8000	DEOS-DUT
H	medi	Medicina	Italy	11.6468	44.5199	50.0000	ASI
RH	mets	Kirkkonummi	Finland	24.3953	60.2175	94.6000	FGI
I	metz	Kirkkonummi (40 km west from Helsinki)	Finland	24.3953	60.2175	94.5000	FGI
H	mikl	Mykolaiv	Ukraine	31.9728	46.9728	94.7000	RIGC
H	mizu	Mizusawa	Japan	141.1328	39.1352	117.0000	GFZ
RH	mkea	Mauna Kea	USA	204.5437	19.8014	3755.0000	JPL
H1	mobj	Obninsk	Russian Federation	36.5697	55.1149	182.6079	GS RAS
H	mobn	Obninsk	Russian Federation	36.5695	55.1149	182.6340	RDAAC-JPL-IRIS
H	mobs	Melbourne	Australia	144.9753	-37.8294	40.0000	GA
	monp	Laguna Mountains	USA	243.5800	32.8900	1842.5200	SIO
H	morp	Morpeth	England	358.3145	55.2128	144.4000	NCL
H	mqzg	Christchurch	New Zealand	172.6547	-43.7027	154.6800	GNS
	~~msku~~	~~Franceville~~	~~Gabon~~	~~13.5520~~	~~-1.6312~~	~~387.0000~~	~~JPL~~
I	mtbg	Mattersburg	Austria	16.4043	47.7379	294.0000	BEWAG
I	mtka	Mitaka	Japan	139.5614	35.6795	109.0000	ENRI
	nain	Nain	Canada	298.3113	56.5370	33.4800	NRCan/GSD
	nama	Namas	Saudi Arabia	42.0446	19.2114	2703.2212	MIT
H	nano	Nanoose Bay	Canada	235.9135	49.2948	6.0000	GSC
RH1	nico	Nicosia	Cyprus	33.3964	35.1409	155.0000	BKG
N	nist	Boulder	USA	254.7374	39.9951	1648.4880	NIST
	nisu	Boulder	USA	254.7378	39.9954	1653.9000	NIST
H	nium	Alofi	Niue	190.0729	-19.0766	90.1000	GNS
RH	nklg	Libreville	Gabon	9.6698	0.3523	31.3870	CNES
RH	nlib	North Liberty	USA	268.4251	41.7716	207.0648	JPL
H	nnor	New Norcia	Australia	116.1927	-31.0487	234.9840	ESOC
RH	not1	Noto	Italy	14.9898	36.8761	126.2000	ASI
I	novm	Novosibirsk	RUSSIA	82.9095	55.0305	149.9800	IMVP
	~~npld~~	~~Teddington~~	~~United Kingdom~~	~~359.6604~~	~~51.4210~~	~~72.7000~~	~~NPL~~
RH	nrc1	OTTAWA	CANADA	284.3762	45.4542	82.4800	NRCan/GSD
RH	nril	Norilsk	Russian Federation	88.3598	69.3618	47.8937	CMIS
H	nrl1	Washington	U.S.A.	282.9756	38.8208	-26.0100	NRL
	nrmd	NOUMEA	FRANCE	166.4849	-22.2283	160.3800	DITTT
H	nssp	Yerevan	Republic of Armenia	44.5029	40.2265	1194.7548	JPL
H1	ntus	Singapore	Republic of Singapore	103.6799	1.3458	79.0000	DUT
	nvsk	Novosibirsk	Russia	83.2355	54.8406	123.6429	IPGG SB RAS
R	nya1	Ny-Alesund	Norway	11.8653	78.9296	84.0000	NMA
R	nyal	Ny-Alesund	Norway	11.8700	78.9300	82.0000	NMA
	~~obe2~~	~~Oberpfaffenhofen~~	~~Germany~~	~~11.3000~~	~~48.1000~~	~~651.0000~~	~~GFZ Potsdam~~
RH1	ohi2	O'Higgins	Antarctic Peninsula	302.0987	-63.3211	33.1000	BKG
RH1	ohi3	O'Higgins	Antarctic Peninsula	302.0986	-63.3211	32.1500	BKG
RH1	onsa	Onsala	Sweden	11.9255	57.3953	45.5000	LMV
	opmt	Paris	France	2.3349	48.8359	124.2000	OP
H1	orid	Ohrid	Macedonia	20.7941	41.1273	773.0000	BKG
H1	osje	Osijek	Croatia	18.6805	45.5608	153.9000	CGI
N	osn1	Osan	South Korea	127.0240	37.0776	48.9000	NGA
N	osn2	Osan	South Korea	127.0240	37.0776	48.9000	NGA
H	ous2	Dunedin	New Zealand	170.5109	-45.8695	26.1000	GFZ-OU
H	pado	Padova	Italy	11.8961	45.4112	64.7000	UNIPD
	parc	Punta Arenas	Chile	289.1201	-53.1370	22.0000	G2
H1	park	Parkes	Australia	148.2646	-32.9988	397.4000	GA
RH1	pdel	Ponta Delgada	Portugal	334.3372	37.7477	110.8000	IGP
H1	penc	Penc	Hungary	19.2815	47.7896	291.8000	FOMI SGO
RH	pert	Perth	Australia	115.8852	-31.8019	12.9200	ESOC
RH	petp	Petropavlovsk-Kamchatka	Russian Federation	158.6070	53.0667	211.0343	KOMSP
H	pets	Petropavlovsk-Kamchatka	Russian Federation	158.6501	53.0233	102.2000	KOMSP
H	pic1	PICKLE LAKE	CANADA	269.8380	51.4798	315.1000	NRCan/GFZ
RH	pie1	Pie Town	USA	251.8811	34.3015	2347.7109	JPL
RH	pimo	Quezon City	Philippines	121.0777	14.6357	95.6920	JPL
	pin1	Pinyon Flat	USA	243.5400	33.6100	1256.1600	SIO
RH	pol2	Bishkek	Kyrghyzstan	74.6943	42.6798	1714.2000	JPL
RH	polv	Poltava	Ukraine	34.5429	49.6026	178.1000	RIGC
RH	pots	Potsdam	Germany	13.0700	52.3800	174.0000	GFZ
N I	pove	Porto Velho	Brasil	296.1037	-8.7093	119.6000	IBGE
H	prds	CALGARY	CANADA	245.7065	50.8713	1247.9400	NRCan/GSD
N	pre1	Pretoria	South Africa	28.2240	-25.7463	1416.4000	NGA
N	pre2	Pretoria	South Africa	28.2240	-25.7463	1416.4000	NGA
H	ptbb	Braunschweig	Germany	10.4597	52.2962	130.2000	BKG
RH	qaq1	Qaqortoq / Julianehaab	Greenland (Denmark)	313.9522	60.7152	110.4000	DNSC
	qiki	Qikiqtarjuaq (Baffin Island)	Canada	295.9663	67.5593	13.3000	NRCan/GSD
N	qui1	Quito	Ecuador	281.5064	-0.2152	2922.6000	NGA
N	qui2	Quito	Ecuador	281.5064	-0.2152	2922.6000	NGA
RH	quin	Quincy	USA	239.0556	39.9746	1105.7651	JPL
RH	rabt	Rabat	Morocco	353.1457	33.9981	90.0854	UNAVCO
R	ramo	Mitzpe Ramon	Israel	34.7631	30.5978	893.1000	GSM
H	rbay	Richardsbay	South Africa	32.0784	-28.7955	31.7927	HRAO
I	rcmn	NAIROBI	KENYA	36.8938	-1.2210	1607.5400	RCMRD
N I	reci	Recife	Brasil	325.0485	-8.0510	20.2000	IBGE
	reso	Resolute (Cornwallis Island)	Canada	265.1067	74.6908	34.9000	NRCan/GSD
R	reun	Le Tampon	France	55.5717	-21.2083	1558.4000	IGN
RH1	reyk	Reykjavik	Iceland	338.0445	64.1388	93.1000	BKG
H	riga	Riga	Latvia	24.0587	56.9486	34.7000	LUAI
H	rio2	Rio Grande	Argentina	292.2489	-53.7855	32.0000	GFZ Potsdam
	riop	Riobamba	Ecuador	281.3489	-1.6506	2817.1880	JPL
N	roap	San Fernando	Spain	353.7937	36.4643	73.7000	ROA
	~~sach~~	~~Pinemeadow~~	~~USA~~	~~243.3900~~	~~33.6100~~	~~1393.7500~~	~~SIO~~
	rock	Simi Valley	USA	241.3200	34.2400	553.3900	USGS
N I	salu	São Luis	Brasil	315.7875	-2.5935	18.9000	IBGE
RH	sant	Santiago	Chile	289.3314	-33.1503	723.0746	JPL
H	sask	Saskatoon	Canada	253.6016	52.1963	580.0000	NRCan/GSD
H1	sass	Sassnitz Island of Ruegen	Germany	13.6433	54.5136	68.2000	BKG
N I	savo	Salvador	Brasil	321.5677	-12.9392	76.3000	IBGE
RH	sch2	SCHEFFERVILLE	CANADA	293.1674	54.8321	498.1800	NRCan/GSD
	scip	San Clemente Island	USA	241.5100	32.9100	452.8500	SIO
H	scor	Scoresbysund/Ittoqqoormiit	Greenland(Denmark)	338.0497	70.4853	128.5000	DNSC
RH	scub	Santiago de Cuba	Cuba	284.2377	20.0121	21.9500	GFZ
	sele	Almaty	Kazakstan	77.0168	43.1791	1340.0000	JPL

RH	seyl	La Misere	Seychelles	55.4794	-4.6737	537.9123	JPL
	sfdm	Piru	USA	241.2500	34.4600	291.5000	UNAVCO
RH	sfer	San Fernando	Spain	353.7944	36.4643	85.8000	ROA
H	shao	Sheshan	China	121.2004	31.0996	22.0901	JPL
	she2	Shediac	Canada	295.4480	46.2207	-15.3000	NRCan/GSD
H	simo	Simonstown	South Africa	18.4396	-34.1879	39.4910	HRAO
H	sio3	La Jolla	USA	242.7500	32.8600	34.8800	SIO
	slor	San Lorenzo	Honduras	272.5635	13.4239	11.9950	IGN-HO
	snil	San Nicolas Island	USA	240.4800	33.2500	239.6900	USGS
HI	sofi	Sofia	Bulgaria	23.3947	42.5561	1119.6000	BKG
	~~sola~~	~~Solar Village~~	~~Saudi Arabia~~	~~46.4006~~	~~24.9107~~	~~760.1393~~	~~JPL~~
	spk1	Saddle Peak	USA	241.3500	34.0600	440.1400	USGS
HI	spt0	Boras	Sweden	12.8913	57.7150	219.9000	LMV
	ssia	San Salvador	El Salvador	270.8838	13.6973	664.4000	CNR
RH	stjo	ST. JOHN'S	CANADA	307.3223	47.5952	152.8400	NRCan
H	stk2	Shintotsukawa	Japan	141.8448	43.5286	118.5400	GSI
HI	str1	Canberra	Australia	149.0101	-35.3155	799.9640	GA
HI	str2	Canberra	Australia	149.0169	-35.5319	799.9540	GA
H	sulp	Lviv	Ukraine	24.0145	49.8356	370.5000	RIGC
I	sunm	BRISBANE	AUSTRALIA	153.0352	-27.4849	92.0000	NR&M
RH	suth	Sutherland	South Africa	20.8105	-32.3802	1799.7659	HRAO
H	sutm	Sutherland	South Africa	20.8109	-32.3814	1797.6000	GFZ Potsdam
	suva	Suva	Fiji	178.4252	-18.1459	73.0000	PGPSF
H	suwn	Suwon-shi	Korea	127.0542	37.2755	83.9322	NGII
HI	svtl	Svetloe	Russia	29.7809	60.5329	77.1000	IAA
H	sydn	Sydney	Australia	151.1504	-33.7809	85.6130	GA
RH	syog	East Ongle Island	Antarctica	39.5837	-69.0070	50.0902	GSI
	tabl	Wrightwood	USA	242.3200	34.3800	2228.0300	USGS
N	tah1	Papeete	Tahiti	210.3938	-17.5770	99.9270	NGA
N	tah2	Papeete	Tahiti	210.3938	-17.5770	99.9270	NGA
	tcms	Hsinchu	Republic of China	120.9874	24.7980	77.2607	NML
	tehn	TEHRAN	IRAN	51.3341	35.6973	1194.5700	NCC
	tgcv	Palmeira	Republic of Cape Verde	337.0172	16.7548	35.0000	PGPSF
RH	thti	Papeete	Tahiti, French Polynesia	210.3937	-17.5769	98.0400	CNES
HI	thu2	Thule Airbase	Greenland(Denmark)	291.1750	76.5370	36.1000	NSI
RH	thu3	Thule Airbase	Greenland	291.1750	76.5370	36.1000	DNSC
H	tid1	(Near) Canberra	Australia	148.9800	-35.3992	665.3627	GA
	~~tid2~~	~~Tidbinbilla~~	~~Australia~~	~~148.9800~~	~~-35.3992~~	~~665.3719~~	~~JPL~~
RH	tidb	Tidbinbilla	Australia	148.9800	-35.3992	665.3719	JPL
HI	titz	Titz	Germany	6.4316	51.0353	155.6000	BKG
RH	tixi	Tixi	Russian Federation	128.8664	71.6345	46.9847	TIXI
HI	tixj	Tixi	Russian Federation	128.8664	71.6345	47.0509	SST YEMSP GS SB RAS
H	tlse	Toulouse	France	1.4808	43.5607	211.6000	CNES
	tnml	Hsinchu	Republic of China	120.9873	24.7980	75.8599	NML
	torp	Torrance	USA	241.6700	33.8000	-5.2000	USGS
RHI	tow2	Cape Ferguson	Australia	147.0557	-19.2693	87.3860	GA
R	~~trab~~	~~Trabzon~~	~~Turkey~~	~~39.7756~~	~~40.9947~~	~~99.2000~~	~~BKG~~
	trak	Irvine	USA	242.2000	33.6200	115.5600	SIO
R	trol	Tromsoe	Norway	18.9396	69.6627	138.0000	Kartverket
R	trom	Tromsoe	Norway	18.9383	69.6639	132.0000	NMA
H	tsk2	Tsukuba	Japan	140.0871	36.1056	69.9300	GSI
RH	tskb	Tsukuba	Japan	140.0875	36.1057	67.3000	GSI
	tubi	Gebze	TURKEY	29.4507	40.7867	221.8310	TUBITAK
	tukt	Tuktoyaktuk	Canada	227.0057	69.4382	1.5400	NRCan/GSD
	twtf	Taoyuan	Republic of China	121.1645	24.9536	203.1220	TL
	uclp	Los Angeles	USA	241.5600	34.0700	111.5600	USGS
H	uclu	Ucluelet	Canada	234.4584	48.9256	10.0000	GSC
N I	ufpr	Curitiba	Brasil	310.7690	-25.4484	925.8000	IBGE
RH	ulab	Ulaanbataar	Mongolia	107.0500	47.6700	1611.7000	GFZ
HI	unbj	Fredericton	Canada	293.3583	45.9502	22.7500	UNB
I	~~unfe~~	~~FERRARA~~	~~ITALY~~	~~11.5995~~	~~44.8330~~	~~81.0100~~	~~ASI~~
RH	unsa	Salta	Argentina	294.5924	-24.7275	1257.8000	GFZ Potsdam
HI	urum	Urumqi	China	87.6300	43.5900	856.1000	GFZ
	uscl	Los Angeles	USA	241.7100	34.0200	21.9300	USGS
H	usn3	Washington	U.S.A.	282.9337	38.9206	57.5190	USNO
RH	usno	Washington	USA	282.9338	38.9190	48.8880	USNO
H	usud	Usuda	Japan	138.3620	36.1331	1508.6193	JPL
H	uzhl	Uzhgorod	Ukraine	22.2976	48.6320	232.0000	MAO
N H	vacs	Vacoas	Mauritius	57.4970	-20.2971	420.4000	JPL
H	vald	VAL D'OR	CANADA	282.4358	48.0971	312.7800	NRCan/GFZ
	valp	Valparaiso	Chile	288.3739	-33.0272	31.0000	G2
R	vesl	Vesleskarvet	Antarctica	357.1583	-71.6738	862.4000	HartRAO
RH	vill	Villafranca	Spain	356.0480	40.4436	647.5000	ESOC
HI	vis0	Visby	Sweden	18.3673	57.6539	79.8000	LMV
	vndp	Vandenberg Air Force Base	USA	239.3800	34.5600	-11.5100	UNAVCO
	wab2	Wabern	Switzerland	7.4642	46.9237	611.0000	METAS
HI	warn	Rostock-Warnemuende	Germany	12.1014	54.1698	50.7000	BKG
N	wdc3	Washington D.C.	USA	282.9337	38.9206	57.8720	NGA
N	wdc4	Washington D.C.	USA	282.9337	38.9206	57.8720	NGA
N	wel1	Wellington	New Zealand	174.7787	-41.2726	46.9000	NGA
N	wel2	Wellington	New Zealand	174.7787	-41.2726	46.9000	NGA
RH	wes2	Westford	USA	288.5060	42.6130	86.0170	NOAA-NGS
H	wgtn	Wellington	New Zealand	174.8059	-41.3235	26.0600	GNS
RH	whit	WHITEHORSE	CANADA	224.7779	60.7505	1427.0000	NRCan/GSD
	widc	Sky Valley	USA	243.6100	33.9300	445.0400	SIO
RH	will	Williams Lake	Canada	237.8322	52.2369	1096.0000	GSC
H	wind	Windhoek	Namibia	17.0894	-22.5749	1734.7000	GFZ
	wlsn	Mt. Wilson	USA	241.9400	34.2300	1705.2700	USGS
HI	wroc	Wroclaw	Poland	17.0619	51.1131	181.0000	IGG WUELS
H	wslr	Whistler	Canada	237.0788	50.1265	909.0000	GSC
RH	wsrt	Westerbork	The Netherlands	6.6045	52.9146	86.0000	DUT
H	wtza	Koetzting	Germany	12.8789	49.1442	666.0000	BKG
HI	wtzj	Bad Koetzting	Germany	12.8789	49.1442	665.9000	BKG
RHI	wtzr	Bad Koetzting	Germany	12.8789	49.1442	666.0000	BKG
H	wtzs	Bad Koetzting	Germany	12.8786	49.1448	663.4000	BKG
HI	wtzz	Bad Koetzting	Germany	12.8789	49.1442	665.9000	BKG
R	wuhn	Wuhan City	P.R. China	114.3573	30.5317	25.8000	WHU
	xian	Lintong	P.R.C.	109.2215	34.3687	81.5686	CAS-JPL
HI	xmis	Christmas Island Indian Ocean	Australia	105.6885	-10.4501	261.5000	GA
H	yakt	Yakutsk	Russian Federation	129.6803	62.0310	103.3700	RDAAC-IRIS
	yakz	Yakutsk	Russian Federation	129.6810	62.0310	100.0644	RDAAC-IRIS
H	yar2	Dongara	Australia	115.3470	-29.0466	241.2967	GA
I	~~yarr~~	~~Dongara~~	~~Australia~~	~~115.3470~~	~~-29.0466~~	~~241.3820~~	~~GA~~
H	yebe	Yebes	Spain	356.9114	40.5249	973.0000	IGN-E
RH	yell	YELLOWKNIFE	CANADA	245.5193	62.4809	181.0000	NRCan/GSD
	yibl	Yibal	Oman	56.1123	22.1865	95.1000	PDO
H	ykro	Yamoussoukro	Cote d'Ivoire	354.7599	6.8706	270.0000	JPL
RH	yssk	Yuzhno-Sakhalinsk	Russian Federation	142.7167	47.0297	91.2887	RDAAC-IRIS

	~~[illegible]~~	~~Lusaka~~	~~Zambia~~	~~28.3110~~	~~-15.4255~~	~~1324.9144~~	~~HRAO~~
H	[illegible]	Zelenchukskaya	Russia	41.5651	43.2884	1166.8000	BKG
HI	[illegible]	Zimmerwald	Switzerland	7.4650	46.8771	956.4000	swisstopo
HI	[illegible]	Zimmerwald	Switzerland	7.4651	46.8771	954.3000	AIUB
RH	[illegible]	Zimmerwald	Switzerland	7.4653	46.8771	956.7000	AIUB
H	[illegible]	Zwenigorod	Russia	36.7600	55.7000	272.0000	GFZ

This page last updated: 13 Nov 2008

Please send comments about this website to: IGS Central Bureau.

Muhammad Zahied Bin Mohd Noor,
Universiti Teknologi Petronas (UTP),
Bandar Seri Iskandar,
31750 Tronoh,
Perak Darul Ridzuan.

Headmaster,
Sekolah Kebangsaan Gopeng,
Perak Darul Ridzuan.

25 November 2008.

Dear Sir/Madam,

<u>Applying for Doing GPS Survey Works at Your Area</u>

From the above matter, I, Muhammad Zahied Bin Mohd Noor, Civil Engineering student from UTP, would like to get your permission to do GPS Survey Works at the

2. For your information, I am doing my final year project and for the purpose of it, I need to use the GPS station which is located in your area.

3. I really hope that you will approve my application and I also appreciate all of your cooperation for this matter.

Thank you.

Sincerely,

(Muhammad Zahied Bin Mohd Noor)